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Pittsburgh Meeting of the Americal Electrochemical Society.

Pittsburgh, the center of the iron and steel industry, a center of chemical engineering activity, and the home of one of the largest electrical manufacturing companies of the world, will be the place of the annual convention of the American Electrochemical Society, to be held in the beginning of May. The selection of Pittsburgh was a logical one after the great success of the symposium of papers on the electrometallurgy of iron and steel, at last year's annual meeting in Niagara Falls. The electric steel furnace is no longer considered with suspicion or contempt by the practical iron and steel man; it is now being recognized as a very useful adjunct to Bessemer-converter and open-hearth steel plants and it is evident that it will be in extended use before many years in steel works all over the country. Among the visits which have been arranged for the convention, there are two to steel works where electric refining furnaces are in operation and in every other respect the very full program of excursions and social functions, printed elsewhere in this issue, is likewise extremely attractive. The program of papers, which has not yet been announced, will, without doubt, be no less interesting. The Pittsburgh meeting should become another milestone in the career of the American Electrochemical Society.

The Decomposition of Carbon Monoxide in the Presence of Catalytic Agents.

A positive definition of a catalytic agent seems difficult. When a substance simply by its presence (without undergoing any change or without participating in the reaction at all) starts a reaction that would otherwise not go on by itself, we call it a catalytic agent. Ostwald defines in general a catalytic agent as one that changes by its presence the velocity of a reaction without entering into the reaction. Perhaps we should add that we speak of a catalytic agent only, if we do not understand the rationale of its action. If we place a well amalgamated pure zinc rod into a sulphuric acid solution it will not dissolve, or only slowly; if we wind a small piece of platinum wire around the zinc rod, the zinc at once dissolves with strong evolution of hydrogen. Of course, we know that we have here a short-circuited galvanic cell, and because we understand the reason, we would hardly speak of the platinum as a catalytic agent in this case. It is the subjective element of mystery that should find expression in a complete positive definition of a catalytic agent. While contact processes are mysterious, they are extremely important and have come very much to the front. A very small amount of catalyzer often exerts a very great influence on the reaction.

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Dr. Zimmermann's paper, printed in this issue, on the decomposition of carbon monoxide in the presence of catalytic

agents at certain temperatures, will be found very interesting from a purely scientific standpoint and with respect to the reactions in the blast furnace. He shows that carbon monoxide will decompose into elementary carbon and carbon dioxide at temperature near 300° C., with cobalt, for instance, as catalyzer. The reaction is still more interesting and curious if iron is used as catalyzer at 445° C. Iron first acts as catalyzer, decomposing CO into CO_2 and C. It is then oxidized according to the equation $Fe + CO_2 = FeO + CO$. The CO is again decomposed by catalytic action and so on. Iron is here not a pure catalizer, while carbon monoxide appears in the peculiar role of an oxidizing agent for iron.

Zinc and Lead Pigments.

In most processes of ore reduction every effort is made to avoid the production of dust and to prevent any oxidation of the valuable constituents of the ore. It is true that volatilization processes have been devised from time to time in which the metallic constituents are driven off as a volatile salt such as the chloride, but they have never proved successful. Lead and zinc ores, however, have been found amenable to volatilization as mixed oxides and sulphates, and their treatment in this manner may become an important adjunct to the pigment and paint industry. The extended use of zinc as a pigment is interesting in view of a tendency toward the proscription of lead in the customary form of white lead, or basic carbonate. This has been especially true in France and Belgium, where laws adverse to the lead industry have been passed. This matter is more fully referred to in an abstract in the Synopsis in this issue. The manufacture of zinc oxide in the United States dates from 1855. Simply stated, the process consists in burning in a blast furnace of suitable construction a mixture of zinc ore and coal or coke, recovering the volatilized zinc oxide in bag houses. Application of the same principle has been made to lead ores and to mixed zinc and lead ores, giving a basic lead sulphate and a mixture of zinc oxide and basic lead sulphate, respectively.

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It will be apparent that the direct production of clean pigments in a process no more complicated than this would be a decided improvement over first reducing the metal from the ore and then reconverting it into pigment. Furthermore, the treatment of a mixed sulphide of zinc and lead is of great value, as it obviates not only the necessity of reduction, but of previous separation of the minerals and this is frequently difficult and never accomplished without loss. Since most of our ores of zinc and lead are sulphides, and therefore amenable to this process, it would seem to be a matter of less moment whether the manufacture and use of white lead are ultimately prohibited or not. Industry is quick to change to a process which promises both technical and financial betterment and never awaits an act of prohibition to drive it to something new. Perhaps the manufacture of pigment by volatilization of the metal from the ore will prove so much more desirable commercially than the corrosion of the reduced metal, that white lead will be retired without resort to legislation, be it wise or foolish. It should not be beyond the range of possibility that some pigment be found to supersede the basic carbonate of lead; and, indeed, if the advocates of basic sulphate of lead, with or without admixture of zinc oxide, are to be believed, the new pigments may be superior to the old.

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If the process should be feasible and profitable, we have an almost unlimited and suitable ore supply, so that the production of zinc and lead pigments by the new method should be limited only by the demand which can be created for them. It is of no commercial importance whether the pigment is a basic carbonate or a basic sulphate, and a manufacturer would just as soon make one as the other. In any event, the lead industry can only profit by these advances and improvements. As a matter of fact, the production of white lead in the United States has been on the wane. This industry reached its zenith in 1904 when the production was 126,336 short tons. In 1907, which was an off year, it dropped to 111,409 tons and was only 116,628 tons in 1908. Imports also have shown a slight tendency to decrease in that period. The production of zinc oxide, on the other hand, has shown a steady increase since 1897, and when the output of zinc-lead pigment is added to this, a decided increase is noticeable. Imports of zinc oxide have also shown a general upward tendency since 1900.

The Chemical Industries of the United States.

The admirable address delivered by Prof. Charles E. Munroe before the American Institute of Chemical Engineers and of which the first part is published in the present issue, gives an excellent sketch, based on the best statistical data available, of the chemical industries of this country, their present very large extent and the much greater possibilities of the future. Professor Munroe is right in pointing out the difficulty of stating exactly what industries should be considered as chemical. It is, after all, a matter of definition and the popular idea of the term "chemical industries" will adapt itself to the economical development of the future; it will depend on the energy and success with which the chemist and chemical engineer make their influence felt in various industries in an advisory and managing capacity. To mention one instance, the metallurgical works proper were formerly considered as an adjunct to the mine and were managed by mining and mechanical engineers. But with progressing specialization, rendered necessary by the more difficult metallurgical problems to be solved for poorer or more complex ores, it has become practice that a metallurgical engineer is made the responsible head of the metallurgical operations proper. But the sphere of interest and activity of the metallurgical engineer is much nearer to that of the chemical engineer than of the mining engineer. In fact, metallurgical engineers may be considered as a special (and very important and influential) class of chemical engineers in general, just as metals are a special class of chemicals.

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The statistical figures of Professor Munroe (of which a great deal more will be found in the concluding part of his paper to be published in our May issue) are interesting in various respects, but special attention should be called to the figures of the percentage changes of wages, cost of raw materials, and price of products in periods of 5 or 10 years. In estimates of the economical working of a chemical or metallurgical plant these changes should be taken carefully into account; to neglect of analysis of costs may be ascribed many fianancial diffi-

culties in the electric lighting and railway field. While Professor Munroe's figures show a steady and healthy growth of the chemical industries of this country, they also emphasize the shortcomings. The fact that the value of "chemicals, drugs and dyes," imported into this country in 1908, amounted to $73,000,000, shows vast possibilities of future developments. Further, almost 50 per cent of our total exports in 1908 consisted of material which had not undergone any degree of manufacture whatsoever. Professor Munroe is right in advising to put in this country into manufactured form the raw materials of this country; this should really be part of the policy of the conservation of natural resources. To one special point Professor Munroe draws special attention: We sit back glorying in our country, its wide extent, its rich resources; and we continue to sacrifice the fertility of our soils to the support of older civilizations and remain content, while ranging ourselves with those nations that live solely on their primary resources, since the balance of trade is in our favor. But chemists know that this condition cannot last; the average fertility of the soil has been growing steadily less. The utilization of the soil as a chemical factory is but one of the broad problems with which the chemist has to deal.

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To one point, not mentioned in Professor Munroe's paper, attention may be called here. It is often said and it is perfectly true within certain limits that the chemical industry of this country is an imported industry and that in many respects we are still far behind Europe. This is true, for instance, for the coal-tar industry, which has undergone such an enormous and splendid development in Germany that it will be a long time before this country can hope to reach the same state of development. But in other fields this country has gone steadily ahead and in one special field this country has been the pioneer of a new chemical industry—the electrochemical industry, which in various ways is specifically American. It is characteristic that it was founded by engineers rather than chemists. Whether Dr. Acheson's prophecy will turn out true that this is the dawn of a great electrochemical era, the future will show. But there can be no doubt that electrochemical methods and processes will steadily increase in commercial importance in many chemical and metallurgical fields; and the brilliant success achieved by the electrochemical industries of this country will be a source of inspiration to all American chemists.

Compromise in Smelter Fume Suits.

Judicious compromise is the order of the day in disputes arising from smelter fumes. With the decision of Judge Hunt still fresh in our memories, wherein he dissolved the injunction obtained by the farmers against the Anaconda company in the famous Montana suit, it is gratifying to note that a compromise has been effected between the litigants in a similar case in Shasta County, California. Judge Hunt's decision in Montana was broadly based on the principle of the greatest good for the greatest number. He regarded smelting as of primarily greater importance than agriculture to the Deer Lodge Valley and dissolved the farmers' injunction on the further ground that the smelting company had exhausted all means known to modern technical skill to control the enormous volume of fume which the plant was producing.

While conditions in California and Montana are not exactly comparable on account of the greater magnitude of metallurgical operations in the latter State, a distinctly progressive step has been made in the compromise of the California suit in that the smelting companies recognize both the possibility and advisability of suppressing fume. So successfully have the chemists and engineers of the smelting companies attacked the fume problem during the past two years, fighting for their very existence, as it seemed, that they have improved greatly on conditions as they existed during the Anaconda suits. Hence any plea of inability on the part of the smelters could not avail now. By the terms of the California compromise, the Mammoth Copper Company agrees to equip its plant with neutralizing and bag-house devices for wholly suppressing the sulphuric and arsenious acids now discharged into the air. The scheme to be used will probably be that adopted in Salt Lake Valley on account of similar suits, in which the sulphuric acid is neutralized by zinc oxide and all solid matter filtered from the gases through the bag house. An additional point in the California compromise is that the gases finally discharged into the air shall not contain more than seventy-five hundredths of 1 per cent of sulphur dioxide by volume. This will require the dilution of the gases by admission of large volumes of air. Both parties to the suit are granted the right and privilege to make inspections to see that the provisions of the compromise are carried out. The smelting company was allowed 90 days to carry out its work.

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Referring again to the conditions in Montana, it may be said that the fume question is by no means permanently settled there. An appeal from Judge Hunt's decision is now in the Circuit Court. Whether the smelting company can be compelled to eliminate the fume nuisance or close down is a question. The magnitude of operations at Anaconda gives rise to conditions that can scarcely be appreciated on first thought. The company has taken cognizance of every known method of handling fume and has had to abandon all on account of the prohibitive expense or inefficiency. Wherefore it is not fair to assume that what is an efficient system for a smaller smelter might just as well be adopted at Anaconda. Many months ago the Anaconda company presented to the court an exhaustive report on the technology and cost of various systems for eliminating fume and showed their impracticability as far as that smelter was concerned. Mr. Mathewson, in charge of smelting operations, showed that a spraying system would give an acid mud difficult to dispose of, and the plant would cost $3,000,000. A sufficiently capacious bag house would cost $2,750,000, and entail a daily expense of $1,800. For the freezing system the plant would cost $4,000,000 and the cost of operation would be $10,000 per day. A zinc oxide neutralizing plant, such as is used in Utah and will be used in California, would cost $3,000,000 and require 500 tons of zinc ore daily. Thus, it will be seen that the problem is one of no mean proportions, although it is not wholly beyond the range of expectation that it will be solved, at least, in a measure. In the meantime, other plants are working on various schemes in a commendable effort to avoid conflicts with other local interests, and, perhaps, the smelter fume suit in the West will soon become a thing of the past.

Pittsburgh Meeting of the American Electrochemical Society.

The preliminary program of the seventeenth general meeting of the American Electrochemical Society, to be held in Pittsburgh on May 5, 6 and 7, has just been issued. The hotel headquarters will be at the Fort Pitt Hotel, quite near the Union Station.

On **Wednesday,** May 4, the secretary will be at the Fort Pitt Hotel and members and guests can register and receive badges after 12 m. At 2 p. m. it is proposed, if a sufficient number of members will be present, to make a visit of inspection to the Technological Testing Plant of the U. S. Geological Survey. Special tests of fuels, explosives and other materials of the highest technical interest will be arranged by the engineers in charge. Whether this visit is to be made will depend on the attendance of the members; all who can be present on this afternoon for this purpose should inform, in advance, the secretary, Dr. J. W. Richards, Lehigh University, South Bethlehem, Pa. Final notice as to whether the visit is assured will be given in our next issue.

On **Thursday,** May 5, a meeting of the board of directors will be held at 9 a. m. at the Fort Pitt Hotel to be followed at 10 a. m. by the annual business meeting of the Society, at which the report of the annual election and the annual report of the board of directors will be presented. This will be followed by a professional session in which a number of papers will be read and discussed.

For the afternoon of Thursday, a number of interesting excursions and visits have been arranged as follows: Alternatives: Park Company's crucible steel mills, Carnegie Steel Company's dried-blast plant at Isabella Furnace, Jones & Laughlin's Steel Works (Talbot continuous steel process), Pennsylvania Lead Smelting Company., Nernst Lamp Factory, Oxy-Acetylene Welding Company.

In the evening at 8 p. m. Dr. L. H. Baekeland will deliver his presidential address at the Fort Pitt Hotel, to be followed by the reading and discussion of papers of general interest.

Friday, May 6, will be devoted to an all-day excursion, leaving Union Station at 8:30 a. m. and visiting the Allegheny Plate Glass Works at Glassmere, the Westinghouse Electric Works at East Pittsburgh, the Firth-Stirling Works at Demmler (where the Héroult electric steel furnace is in operation), the Carnegie Steel Works at Homestead (where a new type of combined open-hearth and electric furnace is in operation). Lunch will be served on the train; return to Pittsburgh at about 5:30 p. m. Cost of the excursion, $1.50 each.

In the evening at 7 p. m. an informal subscription dinner will be held at the Fort Pitt Hotel, followed by "light entertainment by Section Q."

On **Saturday,** May 7, a professional session for the reading and discussion of papers will be held at the University of Pittsburgh, Grant Boulevard. At 1 p. m. lunch will be taken at the Hotel Schenley.

For Saturday afternoon at 2:30 a general public meeting has been planned, the program being of general interest. It includes addresses on the present status of electrochemical industries (illustrated), on the advantages of Pittsburgh as an electrochemical center, and, by an eminent speaker, on the conservation of natural resources of power. Full details of this meeting, which it is hoped to attract a large audience and to arouse general public interest, will be given later on.

This meeting will be followed by visits to the Carnegie Institute and Museums, Carnegie Technical Schools, University of Pittsburgh, and other points of interest in the vicinity of the Carnegie Music Hall.

In the evening members staying in the city will be invited to an "at home" at one of the local clubs.

The above program is subject to modification in any of its details. The final program, including the titles of papers to be presented, will be printed in our next issue.

Ladies are cordially welcomed to the meeting; their comfort and entertainment will be in the hands of a Ladies' Committee, and they are invited to attend the sessions, the dinner on May 6, the luncheon on May 7 and the excursions on May 4, 5 and 7.

A fine program and a highly interesting meeting is assured and the Local Pittsburgh Committee hopes to see a record-breaking attendance at the first gathering of the Society in Pittsburgh.

American Institute of Chemical Engineers.

The summer meeting of the American Institute of Chemical Engineers will be held at Niagara Falls, N. Y., June 22 to 24, 1910.

A prominent feature of the meeting will be visits to the important and interesting chemical industries in this locality.

American Foundrymen's Association.

The convention of the Allied Foundry Associations will be held in Detroit, Mich., June 6-10, 1910. Committees of the American Foundrymen's Association and American Brass Founders' Association are engaged in making the convention the best that has yet been held. An exhibit of mechanical equipment will be an interesting feature and extensive arrangements are being made for visitation of plants. The headquarters of the convention will be at the Pontchartrain Hotel. Information regarding the convention can be secured from Mr. Frank T. F. Stephenson, chairman of the general convention committee, 12-14 West Atwater Street, Detroit, Mich.

Chandler Testimonial.

In our February issue (page 65) we recorded the fact that after a very long period, almost a lifetime, of the most useful activity as head of the department of chemistry and dean of the School of Mines of Columbia University, Dr. Charles F. Chandler will retire from his duties at the end of the coming term, to be appointed professor emeritus of chemistry.

To commemorate this important epoch of his life the following organizations have taken the initiative in planning for a testimonial to be tendered to Dr. Chandler by the chemists of the United States: The Chemists' Club, the Society of Chemical Industry, the American Chemical Society, the American Electrochemical Society, the American Institute of Chemical Engineers and the Verein Deutscher Chemiker.

The form of this testimonial has been arranged, firstly, in form of a banquet at the Waldorf-Astoria, on Saturday, April 30, at 7 p. m. The cost of each dinner ticket will be $5, a sum, which, while not sufficient to defray the expenses, will insure a large attendance. Ladies will be admitted to the galleries and light refreshment served them at a nominal charge of $1 per person.

At this banquet a bronze bust of Dr. Chandler, in heroic size, to be executed by the famous sculptor, Mr. J. Scott Hartley, will be presented to him. This bust will finally be presented to the Chandler Museum of Columbia University. A replica of this bust is to be presented to Mrs. Chandler.

Finally, a Chandler Testimonial Fund will be created for the purpose of purchasing books for the library of the Chemists' Club.

Subscriptions for the banquet and the general expenses of the testimonial are to be sent to the treasurer of the committee of arrangements, Dr. Morris Loeb, 273 Madison Avenue, New York.

Mr. I. F. Stone is the chairman and Dr. Charles F. McKenna, 50 Church Street, New York, the secretary of the committee.

International Congress of Inventors.

The "International Congress of Inventors" was established in 1906, with headquarters in Rochester, N. Y., and incorporated in 1907. One of the objects of the congress is "to endeavor to establish a standing for a United States patent independent of any court action." Mr. George F. Gallagher is the president, Mr. Ralph T. Olcott the secretary. The headquarters are at 123-125 Ellwanger & Barry Building, Rochester, N. Y.

Under the auspices of the congress a "national convention of inventors" and exhibition of patents and models will be held at Rochester, N. Y., from June 13 to 18, 1910.

The Iron and Steel Market.

Each year in the American iron trade has shown a distinct color, and the current one is proving no exception, presenting a color so novel as to perplex the majority. We have had the spectacular boom of 1899, the quick reaction of 1900, the steady growth in prices and demand in 1901, the feverish activity of 1902, the reaction of 1903, the melancholy dullness of 1904, the sharp revival of 1905, the sustained improvements of 1906, the storm of 1907, the much talk and little performance of 1908, and the stupendous recovery of 1909. Through all these vicissitudes there has been created the machinery for doing an enormous amount of business with a minimum of noise and confusion, but unprepared by recent example for such performance, the iron and steel trade stands confused and is alternately looking for improvement and fearing a reaction, at a time when production of both pig iron and steel is at the highest rate ever recorded, passing by 20 per cent the average of the best previous calendar year, while close to 100 per cent of the tonnage produced is passing quietly into consumption and the small tonnage which may possibly be accumulating in the hands of mills and jobbers is bound to be distributed promptly on the appearance of really spring weather conditions.

This line of treatment may seem fanciful, but the solid ground for it can be shown by analysis of history. One must, in fact, go back to 1890 to find similar conditions. Then, despite the fact that the industry was much smaller than now, identical conditions were presented. There had been a reaction in 1887, a dull period in 1888, and a somewhat feverish recovery in 1889. In the early months of 1890 conditions were precisely similar, at all comparable points, with the present. Tonnage was enormous according to the then scale, yet the market moved doubtfully and prices showed a slight receding tendency. Throughout that year the market doubts continued, and yet it ended by disclosing a pig iron output 21 per cent in excess of the best previous record. If like conditions produce like results, we shall find, for this year, a maintenance of the present production rate, without realizing where all the demand comes from, and a substantial maintenance of prices, though with occasional slight recessions. Hitherto in recent years when the demand for iron and steel reached new tonnage proportions it strained the existing capacity and resulted in delayed deliveries and advancing prices; at this time there is no strain upon productive capacity, for it has been very largely increased since the last test, in the first 10 months of 1907.

Late in February a slight improvement occurred in demand for finished steel products, which was continued until nearly the middle of March. The tone of the market improved concurrently, and confident predictions were made of a continuance of the improvement. About the middle of the month the market experienced a slight chill, from which in due course it will no doubt recover.

Pig Iron.

The theory that because Lake Superior ores were advanced 50 cents for the coming season pig iron for second-half delivery would necessarily be higher than for first-half delivery was abandoned when, early in the month, the Westinghouse Electric & Manufacturing Company bought foundry iron for second-half delivery, 5000 tons for its Allegheny works, in Pittsburgh, at $16.50 delivered, and 10,000 tons for its Cleveland works at $16.75 delivered. The Pittsburgh iron was at a lower price than had been done for early delivery, while the Cleveland iron was at no more than a trifle above the ruling market for early delivery. In other districts pig-iron business was done at slight recessions from former prices, and Southern iron was done at $12.50, Birmingham, for May and June delivery. While the pig-iron market may not show a condition of total depravity, it is at least not in good form that when Northern iron failed to show a higher price for second half, on account of the advance in Lake ores, the Southern pig-iron industry, which is self-contained, should show lower prices for prompt than for second-half delivery, yet such is the case. Prices at valley furnaces (90 cents higher delivered Pittsburgh) are substantially as follows: Basic, No. 2 foundry and malleable, $16 to $16.25; gray forge, $15.25 to $15.50; Bessemer, $17.75. The price on Bessemer represents a decline of 25 cents, early in the month, brought about by sales of 10,000 tons to the Cambria Steel Company and 7000 tons to the Lackawanna at a nominal price of $18, valley furnace, but with an allowance of three months' interest.

Steel.

A large tonnage of billets and sheet bars has been moving on old contracts, while new business has been very light. There is occasional demand for open-hearth billets, particularly small sizes, which are scarce. Quotations remain at $27 to $27.50 for Bessemer billets, $27.50 to $28 for open-hearth billets, $28.50 to $29 for sheet bars and $33 for rods, all f.o.b. maker's mill, Pittsburgh or Youngstown districts. The Carnegie Steel Company has put in operation the last of the four 55-ton open-hearth furnaces at the Homestead Steel Works on which construction was commenced last summer. This gives the Homestead works 64 open-hearth furnaces and one electric furnace.

Finished Products.

Prices in the main show no change, but one or two products have trended slightly to weakness. Iron bars are a trifle easier in the Pittsburgh and valley districts, but are still quotable at $1.65 to $1.70, Pittsburgh, while the Chicago market has declined $1 a ton to $1.50, Chicago, and the St. Louis market has experienced a rather sharp drop of $2 a ton, sales being made at $1.40 at mill, St. Louis district. Shading of a dollar a ton has appeared in corrugated sheets, flat sheets being well maintained. Wire products show less shading than a month ago. Line pipe is being cut rather freely, while merchant pipe is nominally unchanged. While the price of $1.55, Pittsburgh, on plates and shapes remains for the Pittsburgh and Western markets, the shading of a dollar a ton from this basis continues in the Eastern market.

While there is no general buying movement in finished steel product, a good tonnage is being booked from week to week, the aggregate falling only a little short of current production, and with the large volume of business on books in most lines it would take a long time for orders to run out, while progress into the spring is expected to take up the slack very soon.

Regular prices, f.o.b. Pittsburgh, are as follows:

Standard steel rails, $28 for Bessemer; $30 for open-hearth, f.o.b. mill, except Colorado.

Plates, $1.55 for tank quality, ¼ in. and heavier.

Shapes, $1.55 for I-beams and channels, 15 in. and under, zees and angles, 2 x 3 and larger.

Steel bars, $1.45 to $1.50, base.

Iron bars, $1.65 to $1.70, Pittsburgh; $1.55 to $1.60, Philadelphia; $1.50 to $1.55, Chicago; $1.40 to $1.45, St. Louis.

Wire nails, $1.85, base; plain wire, $1.65; galvanized barb wire, $2.15.

Black sheets, 28-gage, $2.40; galvanized, $3.50; blue annealed, 10-gage, $1.75 to $1.90; painted corrugated roofing, $1.70 per square; galvanized, $3.

Tin plates, $3.60 for 100-lb. cokes.

American Institute of Electrical Engineers.

At Charlotte, N. C., March 30-31 and April 1, will be held a meeting of the American Institute of Electrical Engineers.

Seven papers will be presented at this meeting as follows: "Electric Drive in Textile Mills," by Mr. Albert Milmow; "Gas Engines in City Railway and Light Service," by Mr. E. D. Latta, Jr., Charlotte Electric Railway, Light & Power Company; "The proportioning of Electrodes for Electric Furnaces," by Mr. Carl Hering, of Philadelphia; "Modifications of Hering's Law of Furnace Electrodes," by Dr. A. E. Kennelly, of Harvard University; "Some Demonstrations of Lightning Phenomena," by Prof. E. E. F. Creighton, of Schenectady; "Economics of Hydroelectric Plants," by Mr. W. S. Lee, chief engineer, Southern Power Company; "Method of Protecting Insulators from Lightning and Power Effects," by Mr. L. C. Nicholson, electrical engineer, Niagara, Lockport & Ontario Power Company, Buffalo, N. Y.

A special train de luxe for visitors from the North will be provided by the Pennsylvania Railroad should at least 100 passengers be assured. Applications for reservations should be made in advance to the A. I. E. E. headquarters, 29 West Thirty-ninth Street, New York, in order that the railroad may know if the condition as to number of passengers will be complied with. The train will be made up of parlor, smoking car, observation car, and the most modern sleepers and compartment cars available, and will be electrically lighted throughout.

As the climate of Charlotte is particularly delightful during the season when the meeting will be held, a large attendance is anticipated, which may reach 500 members and guests. Such a meeting is a novelty in the South, and the prominent men of Charlotte and surrounding towns are particularly interested in making it a great success. The committee on entertainment are much pleased with the lively interest taken by the ladies of Charlotte in the social program, and it is anticipated that the reception and dance in the Auditorium on Thursday evening, March 31, will be a particularly agreeable affair. Another feature that doubtless will be much appreciated by visitors is the trip arranged for the delegates, their wives and friends on Friday, April 1, by special train, to the two great generating plants at Great Falls and Rocky Creek, a detail of which is a Southern barbecue near the site of the former. On Wednesday afternoon there will be a visit to some of the electrically operated cotton mills near Charlotte, and on Thursday afternoon a reception to the visiting ladies will be given by Mrs. Stuart W. Cramer at her residence.

CORRESPONDENCE

Efficiency of Drying Machines.

To the Editor of Metallurgical and Chemical Engineering:

SIR:—The exact use of words, always a desideratum, is especially necessary in scientific and technical literature and writers on technical matters cannot be too careful in choice of words, precisely to express what is meant.

As far as I am aware, the word "efficiency" as applied to machines in the accepted technical use, always means the ratio of actual useful effect to the theoretical or ideally perfect effect.

The "efficiency" of a machine is expressed by a fraction, the numerator being the attained result and the denominator the theoretical possibility, or

$$\text{Efficiency} = \frac{\text{Actual result}}{\text{Theoretical possibility}}$$

Of course, if expressed as a percentage, it will be 100 times this fraction.

Now the denominator of the above fraction, the theoretically possible result, is never practically attainable with any machine.

If we consider, for instance, the efficiency of an engine, 100 per cent efficiency would mean the ideal theoretical result of an engine working between two given temperatures, T_1 and T_2, and any losses whatsoever in a practical machine would reduce the efficiency, notwithstanding that some, at any rate, of such losses are quite inseparable from the operation of any practical machine.

Similarly with a boiler, "100 per cent efficiency" would mean the complete utilization of the heating power of the fuel in evaporation.

The fact that the waste gases must necessarily be discharged at a temperature higher than that of the steam generated makes it impossible that any practical boiler can reach 100 per cent efficiency. The loss is an entirely necessary one, but nevertheless it equally detracts from the "efficiency" of the boiler.

In an article on the "Efficiency Test of a Direct-Heat Dryer," in your March issue (page 162), efficiency is used in an entirely different sense and one, I believe, quite unwarranted by ordinary scientific usage.

To evaporate a given weight of water from any given temperature requires a definite amount of heat, let us say a b.t.u. A certain quantity of fuel will furnish a definite number of heat units, let us say b b.t.u.

A drying machine receiving b b.t.u. from the fuel burned and utilizing a units in *actual useful evaporation* has an "efficiency" equal to the ratio of a to b.

Now there are certain necessary losses in any drying machine which are well enumerated in the article in question. All of these losses reduce the numerator of the above fraction, and, in any consideration of "efficiency," all of them must be charged against the machine.

Among these losses is that due to heating up the material to the temperature at which it is discharged from the machine. This particular source of loss does not differ from any of the other sources of loss. It is, indeed, a variable, dependent upon the type of machine and upon the material to be dried. Its magnitude will vary with different materials. Nevertheless, in considering the efficiency of a dryer in any given case, the loss due to this cause must be charged against the machine, precisely as must loss from any other cause.

The writer of the article under discussion, however, *credits* the dryer with the heat diverted from useful work in this manner. In other words, he adds the heat required to heat the material to the discharge temperature to the heat required for actual evaporation, and calls the sum of the two "the theoretical heat required."

The ratio between this so-called "theoretical heat required" and that actually expended in useful evaporation he calls the "efficiency."

This is an entirely incorrect use of terms. The true efficiency of the dryer in the case cited is the ratio of heat received to heat utilized in useful work, or (taking the figures in b.t.u. from the article referred to) [illegible], or in round numbers, 54.5 per cent "efficiency."

There is no reason why this particular form of loss should be credited to the dryer any more than any other form of loss. It is indeed an unavoidable loss, but its magnitude is largely dependent upon the type of dryer. In the case discussed, the material was discharged at a very high temperature (224° Fahr.) and consequently the loss was high, notwithstanding the low specific heat of the material.

Had the machine been of a type that discharged its product at a lower temperature, the loss from this source would have been less and the "efficiency" greater.

It is perhaps proper to add that the "efficiency" of a drying machine is a relative matter and depends on the material to be dried.

The efficiency of a drying machine can only be stated for any particular case and may vary widely with different materials.

In the case in point, the material handled (sand) contained only 5 per cent moisture to begin with. Therefore, the weight of dried material discharged was very great relatively to the evaporation, and this condition is not favorable to the realiza-

tion of a high efficiency, particularly in a counter-current machine delivering its product at a high temperature.

The foregoing is not a discussion of any type of dryer, but of a proper use of terms. The performance of the dryer in the test was fair, but in no way remarkable. It evaporated, according to the figures given, 5.62 lb. of water per pound of (very bad) coal fired, or 6.25 lb. water per pound of dry coal. This is probably well up to the average performance of dryers and a good deal nearer the truth than the absurd evaporation figures frequently claimed. Only last month we were favored with an account in your columns of a dryer evaporating 16 lb. of water per pound of combustibles (page 108 of February issue). Such figures are immune from criticism by their very absurdity.

While the figures given in regard to efficiency test under discussion are fairly consistent, they lead to some remarkable conclusions.

The discharge temperature of waste gases is given as 100° Fahr. and the weight of air discharged as 31,905 lb. per hour. This air has to carry off 2250 lb. of water, or each pound of air must carry 0.0705 lb. of water. To do this it would have to be supersaturated to the extent of about 57 per cent; that is, the discharged air would not only require to be completely saturated with vapor, but must carry an additional burden of water in the form of mist (not vapor) equal to 57 per cent of its saturation water. To put it otherwise, something less than two-thirds of the water discharged was actually "evaporated," the rest being discharged, not as vapor, but as liquid water (mist). Of course, it does not matter in what form the water is got rid of as far as the efficiency of the dryer is concerned. Indeed, if it is possible to discharge one-third of the water as liquid water, it opens up a way to extraordinary possibilities in drying economies. Ordinarily, however, it is sufficiently difficult to attain complete saturation, let alone supersaturation.

BAYONNE, N. J. W. E. WADMAN.

* * *

To the Editor of Metallurgical and Chemical Engineering:

SIR:—The above criticism by Mr. Wadman of the dryer test, published in your March issue, was forestalled by paragraph three under heading "Heat in Dried Material." There it was stated: "It is, of course, a matter of definition how much of the heat which is carried off by the dried material should be considered as a loss," and as I stated my position in the matter there could be no possible deception and the discussion resolves itself into an academic discussion of terms which is unprofitable.

I still contend that my method of computation is a fair one. There is a decided difference between the loss in heating the drying material and the other losses enumerated. To attempt to dry sand, rock or most other inorganic materials at a low temperature by absorption would be absurd on account of the small capacity such a process could give. I therefore assume it is *necessary* to heat such material to 212°, just as necessary, in fact, as to heat and evaporate the water contained, so the dryer should be credited in doing this work. It is not necessary to heat the material above 212° (except in special cases); it is not necessary to carry off inconsumed carbon nor to have an excessive temperature of the exhaust air, not of the shell; therefore, such losses should be charged to the dryer.

Regarding the condition of the water and air of the exhaust, the air is probably fully saturated and is accompanied by a considerable quantity of watery vapor which can be as plainly seen as the exhaust from a steam engine. With the type of dryer from which the test in your March issue was made, it is often the case in drying clay or other very wet materials to evaporate 4500 lb. of water per hour with not over 6000 cu. ft. of air per minute passing through the machine. This means there is 88 grains of water carried off for each cubic foot of air, while the air if completely saturated would not hold over 21 grains per cubic foot.

NEW YORK CITY. W. B. RUGGLES.

Energy Losses in Electrodes.

To the Editor of Metallurgical and Chemical Engineering:

SIR:—In the article by the writer on "Current Densities and Energy Losses in Electrodes," published on page 26 of your January issue, there occur some misprints, which should be corrected as follows:

Page 29, second column, second paragragh, line six, stands: "in the case," read: is the case.

Page 30, first column, first paragragh, line three, stands: "in the case," read: is the case.

Page 30, second column, fourth paragraph, line two, stands: (14), read: (15).

Page 31, first column, third paragraph, line eight, stands: $C_1\sqrt{T/d}$, read: $C_1\sqrt{I/a}$.

Page 31, second column, fourth paragraph, line nine, stands: agreement, read: square root.

Page 32, first column, sixth paragraph, line nine, stands: 1.07 volt, read: 0.07 volt.

Page 32, second column, sixth paragraph, line five, stands: extreme, read: electric.

Page 33, first column, sixth paragraph, line six, stands: correction factor, read: correction factor $\sqrt{1/2\,(1-c)}$.

Page 33, first column, eighth paragraph, line five, stands: $\sqrt{\tfrac{1}{2}}\,(1-c)$, read: $\sqrt{1/2\,(1-c)}$.

With reference to the editorial remarks in the same issue regarding this article the writer wants to point out, in order to avoid misconceptions, that his introduction of a coefficient c, appearing as a factor to the Joulean heat loss, ought not to be interpreted as a lumping together of the heat leakage into the surrounding medium with half the Joulean heat loss, but as an expression for the fact that this heat leakage will reduce the efficiency of the "check-valve action" of the Joulean heat upon the heat conduction from the charge. Using the language of the editorial, where H is the heat which would flow if there was no current, the electrode loss is expressed in the following way, when there is heat leakage into the wall: $[H-(1-c)\,i^2r]+i^2r$ as against the theoretical case when no such leakage occurs: $[H-\tfrac{1}{2}\,i^2r]+i^2r$.

HÖGANÄS, SWEDEN. JAKOB FORSSELL.

* * *

Silundum.

To the Editor of Metallurgical and Chemical Engineering:

SIR:—From the letter of Dr. E. G. Acheson in your issue of February I learn that he did not express himself, as reported, at the meeting of the American Electrochemical Society. I see, however, in your number of January that you refer, page 64, to silundum as having the same chemical compositions as siloxicon.

Dr. Acheson states that "in analyzing the possible reactions and the products that may be obtained from these three elements (carbon, silicon, and oxygen) we find that the furnace content may be so proportioned and the furnace so operated as to produce either graphite, metallical silicon, carborundum or amorphous carbide of silicon, or we may have all the three elements so associated as to produce siloxicon. As to the possibility of any other product being made, I am not advised, but the foregoing were old before the world was informed of Mr. Bölling's experiments."

I stated in my original article: "A process was worked out and patented by which it is possible to convert any piece of carbon, in form of tubes, round or square, rods, bricks, crucibles, pieces of coke, charcoal into *silicon carbide*. Silicon carbide was known so far only in the amorphous and crystalline state, and it was supposed that it was formed by the sublimation of silicon and carbon at high temperatures." Silundum, as the new material has been named, or silicified carbon, is, therefore, a product that is obtained when carbon is heated in a vapor of silicon "and, farther on, silundum is another form of silicon carbide."

I am of the opinion that my original article on silundum states clearly that it is a silicon carbide, and I do not see any reason why a discussion should take place on the chemical composition of silundum. If Dr. Acheson reads my original paper he will find that silundum falls under the products named in his letter. I do not claim to have discovered a *new chemical compound*. What I claim is the discovery of a new process to convert any piece of carbon into silicon carbide or covering it with silicon carbide preserving its original shape.

Silundum contains silicon in various percentages. Pieces are found that look like carbon, but are incombustible, others in a farther state of conversion have the appearance of siloxicon and amorphous silicon carbide. The next state is a material that has a metallic appearance; it contains the largest amount of silicon. If pieces of any of these modifications are heated to a higher degree, silundum crystallizes and is converted into carborundum.

Silundum may be converted into graphite in modifying the charge. There seems to be some probability that under certain conditions the black diamond may be obtained from silundum by depriving it of its silicon.

I may say that the hardest modification of silundum is used in some places for boring purposes, replacing the diamond.

Oberwesel, Germany. F. Bölling.

* * *

The Trust from the Standpoint of an Engineer.

To the Editor of Metallurgical and Chemical Engineering:

Sir:—In the March issue of this magazine there appeared an interesting discussion of "The Trust from the Standpoint of an Engineer," by Mr. W. McA. Johnson, evidently inspired by reading the brief for the defense in the action against the American Tobacco Company, brought under the so-called "Sherman Anti-Trust Law." In view of certain statements which appeared in Mr. Johnson's letter, a further short discussion may be of general interest, especially as regards the Supreme Court of the United States.

The fact that the Federal Anti-Trust Act passed in 1890 has remained on the statute books unamended for 20 years tends to show that it was not the product of a discontented minority, but was and is the crystallization of public opinion into law, a law that is worthy of a conclusive test both as to legality and practicability. When the Supreme Court decides a case under this statute, the duty of the justices is simply to construe the law and apply it to the concrete case presented, leaving to the law-making body the responsibility as to the statute's expediency. Now the members of the court will bring to the decision of the Tobacco Company case both ripened expert knowledge of law and an impartial habit of mind, and, furthermore, they will examine *all* the facts in the light of arguments presented by the prosecution, as well as by the defense.

If the Court decides that the facts proven make the Tobacco Company guilty of a misdemeanor as defined in the law made by Congress, Mr. Johnson implies that it will forfeit a large share of his respect. A man who is not an expert in law and who has read simply the argument for the defense (made by a lawyer hired solely because of his ability to present one side of the question) is hardly in a position to criticize a decision reached by the highest of our courts after an impartial and complete examination of all the evidence.

The statement that the "trusts" are necessarily the survival of the fittest and are therefore assured of longevity depends on the meaning attached to the word fit. The simple plan that "they should take who have the power and they should keep who can" has undergone extensive revision in the ascent from barbarism to civilization, so that society to-day compels the takers and keepers to confine their operations within the bounds of necessary laws, which are as real a product of an evolutionary process as anything else.

Mr. Johnson considers one great corporation "fit" because it is approved by public opinion and evidence of this general approval he finds in the fact that the people have not demolished it. The conclusiveness of this reasoning is open to serious question. It is a safe opinion that the majority of American citizens would not resort to physical violence until wrongs far greater than any ever charged against the Standard Oil Company have been proven to them, and then not until the Government, which is established for preserving order and justice, is shown to be unable to cope with the situation. Rather will the average man wait to see the status of the giant monopoly established by the judicial machinery created for that purpose, namely, the Supreme Court of the United States. The legal status being determined (one factor in the judgment of its "fitness") its survival as an economic power will be decided by its future life and prosperity.

If manipulation of prices or other facts show that the trust is guilty of a misdemeanor as defined in the "Sherman Act," and Mr. Johnson thinks those facts should not constitute a misdemeanor, his objections should be aimed not at the Court, but at the law-making body and at the dormant public opinion which permits the law to remain unamended.

Mr. Johnson's dismissal of rebates as special favors to friends and as similar to a discount given to a grocer who promises to handle a single brand of goods, seems inaccurate, for the analogy is superficial. A grocer's business is private, while the railroads are "common-carriers," a class of beings who, even before the steam locomotive was dreamed of, were considered to be under very special obligations to the public. The railroads are the highways of the nation, deriving their rights, the land on which they are built, and their corporate existence from the State. The prevailing idea is that in giving up these highways of commerce to be developed by private enterprise, the State should insist that all its citizens be treated on an equal basis. Instead of being a matter of friendship between carrier and shipper the transaction was often in the nature of a hold-up. The evils of rebating are matters of business history; and public opinion, forcibly expressing itself in the Interstate Commerce Act, has rightly banished the practice.

The "trusts" which control the selling prices of commodities seem in certain industries to be the most efficient form of organization now known and are (as Mr. Johnson states) the result of a process of evolution following definite economic laws. But there exist no economic laws compelling corporation managers to be scrupulous in controlling prices. A few of them at least have not been so. There is nothing in any evolutionary theory that precludes adequate protection of the public welfare; indeed, the general welfare demands that these leaders be subject to the reasonable restraints of the law. It is the opinion of the majority of competent judges that the English common law, which was gray-headed before the beginning of our industrial era and was chiefly developed in a state of society widely different from our own, is inadequate unless revised and amplified. The necessity for such modification is at once a reason and justification for legislation by Congress. This will tend toward an equitable division of the profits resulting from the corporate form of organization among the three parties of interest, namely, the corporation itself, its employees, and the consuming public.

Beginning a little over a century ago with the perfecting of the steam engine and the resultant displacement of hand processes by power-operated machinery, there has come a wonderful creation and development of industries, accompanied by a corresponding revolutionary change in the employment and living conditions of civilized peoples. Also accompanying this evolution there has been a progressive development in the organization of industry, culminating in the "trusts" created within our own time. The institutions and practices which this century of change has produced have existed but a brief interval, historically speaking; they are now on trial, and will be altered or discarded as experience teaches.

Washington, D. C. Ray L. Stinchfield.

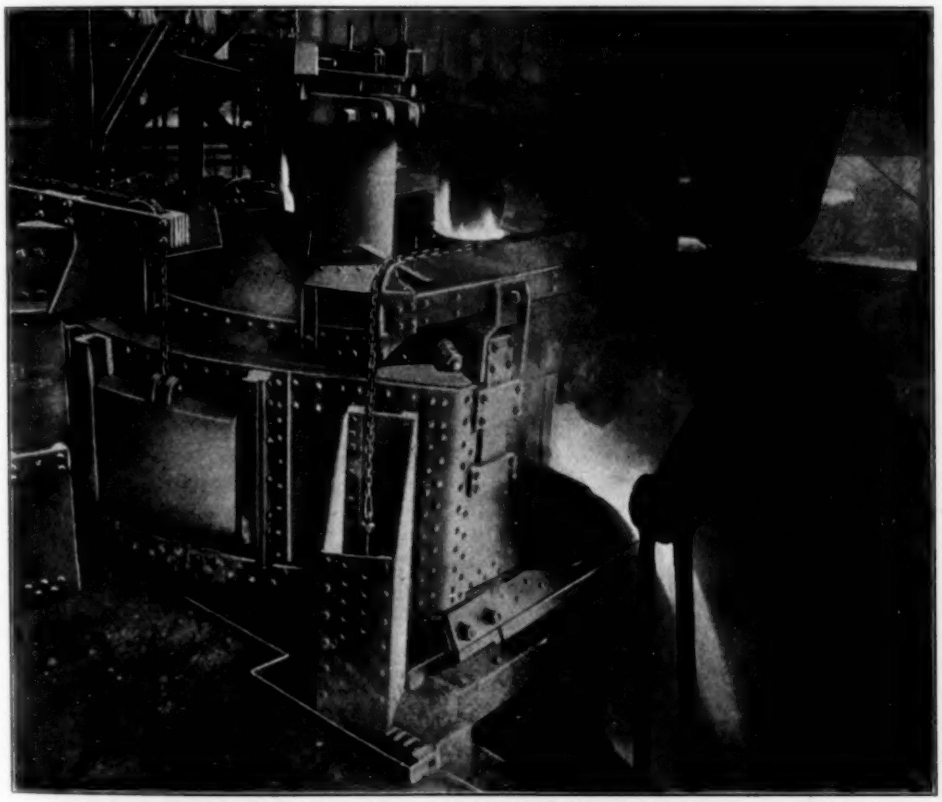
The South Chicago Electric Furnace Plant of the United States Steel Corporation.

When in February of last year the United States Steel Corporation adopted the Héroult electric furnace for steel refining, it was decided to erect, as a beginning, two Héroult furnaces, each of 15 tons capacity, one at the South Chicago works of the Illinois Steel Company and the other at the Washburn & Moen plant of the American Steel & Wire Company, at Worcester, Mass. At South Chicago the electric furnace is used for refining molten metal from the Bessemer converter, at Worcester for refining molten metal from the basic open hearth. The object of the combination of the ordinary acid-lined Bessemer converter and the electric furnace (South Chicago) is to produce steel of open-hearth steel quality or better at less cost. The object of the combination of basic open-hearth and electric furnace (Worcester) is to produce steel better than the best acid open-hearth steel in quality, at a slightly advanced cost.

The undertaking of the United States Steel Corporation involved some interesting and important novel points. The largest Héroult furnaces installed before that time had a capacity of five tons. In the Héroult furnaces of the Steel Corporation this capacity was trebled. Further, the Héroult electric furnace had been used before on a commercial scale with cold charges, and with molten metal from the open-hearth furnace (as in the pioneer American Héroult plant of the Halcomb Steel Company in Syracuse); but in South Chicago it was to be adopted for the first time in America on a large scale in combination with the Bessemer converter. Finally, while in the past the Héroult process had been used essentially as a substitute for the crucible steel process for the manufacture of high-grade tool steels, etc., it entered into a much wider field of usefulness at South Chicago and Worcester, where it is used for large-tonnage products (tonnage steel), like rails, axles and wire.

The South Chicago plant has been in continuous operation since May of last year, while the Worcester plant was started in the beginning of this year. The South Chicago plant is perhaps the more interesting of the two, since it includes the more involved metallurgical process of both dephosphorization and desulphurization of the steel in the electric furnace, while the metal charged from the basic open-hearth into the electric furnace at Worcester is already largely dephosphorized.

Further, the combination of the electric furnace with the Bessemer converter seems a matter of momentous commercial importance. For a number of years the cry of the consumer has been for better steel for many purposes, like rails, etc. As a result, there has been a decided tendency away from the converter and toward the open hearth. Many have prophesied that it would be necessary to use open-hearth steel almost exclusively in future and that the Bessemer converter plants were doomed. If the electric furnace in combination with the Bessemer converter can make as good or better steel at the same or less cost than the open hearth alone, it means that the electric furnace gives a new lease of life to the converter. Far from being a competitor to the old methods of steel metallurgy, the electric furnace becomes the savior of the converter plants and prevents their being scrapped. From this viewpoint the results obtained with electric refining at South Chicago are of broad commercial significance and importance.



HEROULT ELECTRIC STEEL FURNACE AT SOUTH CHICAGO.

By a special invitation extended to us by Dr. Paul Héroult we were enabled to inspect, on March 12, the electric furnace plant of the Illinois Steel Company at South Chicago. The inspection extended almost over the whole day; we were given every possible facility of inspection, while information on all questions asked was given without reserve. Our thanks are due to Dr. Héroult, to Mr. W. A. Field, general superintendent of the Illinois Steel Company, and to the many officials and employees of the Illinois Steel Company who gave us information.

The most important question that will be asked is, of course, whether the Héroult furnace in combination with the Bessemer converter is now beyond the experimental stage. This question must be answered unreservedly in the affirmative. There is nothing experimental whatever about the operation of the Héroult furnace in South Chicago. There is no "fussing" about the furnace. No nervousness is displayed as to whether something might go wrong. The whole operation is carried on with such self-evident certainty and assurance as comes only from firmly established routine.

That the Héroult furnace at South Chicago is a commercial metallurgical apparatus and no longer in the experimental stage is also proved by the regularity with which the heats follow each other. The furnace is in continuous operation during the whole week, and operation is discontinued only on Sunday, the converter plant not working that day. When the converter plant closes down in the night from Saturday to Sunday, the metal from the last converter blow is transferred to the electric furnace and refined; then the electric furnace plant closes down till Monday, when the first metal blown in the converter plant is transferred to the electric furnace.

As an indication of the regularity of operation we give in

Table I the net weight of metal charged, the kw-hours consumed, and the durations of 11 successive heats made on March 10.

TABLE I.

Net weight charged. Lb.	Kw-hours used.	Time.
29,000	2000	1 hour 20 minutes.
28,200	2300	1 " 35 "
28,200	2500	2 " 15 "
28,000	2200	1 " 30 "
26,600	2100	1 " 15 "
26,000	2200	1 " 40 "
25,700	2900	2 " — "
23,000	2500	1 " 35 "
28,000	2400	1 " 35 "
27,000	2300	1 " 35 "
27,400	2700	1 " 45 "

On the average 12 heats are made a day. The figures given under time are the time in hours for which the current was on during each heat. It will be seen that during the 24 hours of this day the current was on for 18 hours and 5 minutes, so that the intervals between the successive heats (during which no electrical energy was consumed) amounted to 5 hours and 55 minutes, or 33 per cent of the whole time.

The average specific energy consumption of the 11 heats of Table I is 88.4 kw-hours per 1000 lb. net weight, or 194.5 kw-hours per net metric ton. In this case the electric furnace treatment, it should be remembered, involved both desulphurization and dephosphorization.

If the charge supplied to the electric furnace is already low in phosphorus, the specific energy consumption is, of course, less. As an example we give in Table II the figures for 9 successive heats made in 12 hours on Jan. 28.

TABLE II.

Net weight Lb.	Kw-hours.	Kw-hours per metric ton.
28,000	1400	110.0
27,600	1700	135.5
27,000	1400	114.1
28,000	1000	78.5
28,000	1300	102.1
28,400	1300	100.8
27,800	1000	79.2
27,600	1500	119.5
28,100	1200	93.9

The average specific energy consumption of the nine heats of Table II is 47.2 kw-hours per 1000 lb. net weight, or 103.8 kw-hours per net metric ton.

As to the electric power supply, it should be stated that the electrical energy is generated by means of gas engines operated with blast furnace gas and that the two plants of the Steel Corporation at South Chicago, Ill., and Gary, Ind., are electrically connected in parallel. The power generation is highly economical. The charge for energy supply, made to the electric furnace plant, is ½ cent per kw-hour actually consumed, as taken from the meters.

As to the reliability with which the desired composition of steel is produced, we give here the specification and analyses of eight successive heats made during part of March 11. In all these cases axle steel was made.

The first line, marked "Specification," gives the desired specified composition of the steel, while the next lines, marked "Analysis," give the analyses of the steel produced in these eight heats.

TABLE III.

		C	S	P	Mn
Specification:	Axle steel	0.35 to 0.45	0.03	0.03	0.37
Analysis:	30,000 lbs.	.45	0.032	0.031	0.49
	29,000 "	.37	.028	.033	.42
	30,000 "	.38	.028	.026	.40
	30,000 "	.35	.031	.037	.38
	30,000 "	.41	.030	.039	.37
	30,000 "	.48	.025	.032	.41
	30,000 "	.42	.030	.027	.44
	30,000 "	.35	.030	.028	.34

It should be said that the above data were not selected by the writer for any particular purpose, but were taken at random from the regular works records.

The regularity of operation which makes the Héroult furnace at South Chicago a thoroughly commercial apparatus is due in no small degree to the simplicity and compactness of construction of the Héroult furnace and the total absence of any complications whatsoever, either electrical or otherwise, with the possible single exception of the electrodes at the top, which will be particularly discussed.

The furnace as used in South Chicago is shown in the adjoining illustrations, Figs. 1 and 2, for which we are indebted to Mr. R. H. Wolff, Dr. Héroult's representative in this country. The Héroult furnace has been so often described in this journal that there is no necessity for any further details at this place. To characterize the design briefly, it is essentially built like the body of an open-hearth furnace, the heat being supplied from the electrodes through the top. There are three electrodes in the South Chicago furnace, since it is operated by three-phase currents.

The simplicity of the construction results in great convenience of repairs of the furnace proper. During the whole period of operation at South Chicago, from May, 1909, until the present, it is stated that there has never been any necessity to stop the Héroult furnace for the sake of repairs.

The lining is kept in good condition by throwing some shovels of broken burnt dolomite into the furnace upon the corroded portions of the hearth. This is done between successive heats and requires not more than a few minutes; no extra help is required. The consumption of dolomite for repairs is given as 10 lb. of dolomite per ton of steel.

The silica roof has been generally repaired or replaced during the regular stop on Sundays. The last roof, however, lasted 129 heats. The replacement of the roof is a very simple matter, a new roof being always kept in reserve.

The banks (side walls) of the present furnace have stood since Nov. 16, 1909, and there is not yet any necessity for reconstructing them.

The cost of repairs is, therefore, very low. It is given as follows: A silica roof costs $60; if it lasts for 129 heats the cost of the roof per ton treated is about 3 cents. The 10 lb. of dolomite ($6 per ton) required for repairing of the lining per ton of steel cost also about 3 cents. Hence, the total cost of repairs of the furnace proper is approximately 6 cents per ton, which is a remarkably low figure.

As to the electrodes, their consumption is given as averaging 6 lb. per ton of steel, and this figure is stated to be true both for graphite and for amorphous carbon. It is the item of the cost of electrodes which, it is expected, can be very materially reduced in future.

The original intention was to use amorphous carbon electrodes. But it was found very difficult to make very large homogeneous carbon electrodes. While with smaller furnaces amorphous carbon electrodes are in satisfactory successful use, the manufacture of such electrodes for the large 15-ton furnace has met with difficulties in baking and it appears that the problems involved have not yet been solved.

In the beginning of operations, when baked amorphous carbon electrodes were used at South Chicago, they frequently cracked at a most inopportune moment, and caused great trouble. Since the quality or strength of the carbon electrodes obtainable did not materially improve, it was necessary to have then recourse to the more expensive graphite electrodes. These have been and are now doing the service very satisfactorily and no such electrode troubles are now experienced. The intention is to try to solve the problems involved in the baking of large durable homogeneous amorphous carbon electrodes, as their use would reduce the cost of the electric refining process considerably. In every respect except higher first cost the graphite electrodes are exceedingly satisfactory.

The electrodes as used at present are made up of Acheson graphite rods, 48 in. long and 8 in. in diameter. Three such rods are butt-connected to a total length of 144 in., and three

such 144-in. rods are arranged side by side to form a single electrode, consisting thus of a solid bundle of three rods, each 144 in. long, and with cross-section a true shamrock. We might say each electrode is made up of three rods in parallel, each rod consisting of three 48-in. rods in series. A water-cooled jacket is provided around each electrode, just above the openings in the roof.

We now give the record of the operation during one complete heat. The temperatures given in this record were measured with a Mesuré-Nouel optical pyrometer by Dr. Jos. W. Richards, who accompanied the editor of this journal in the inspection of the plant:

11 a. m.—Finished steel poured from electric furnace into ladle (temperature 1495° C.) and then from the ladle into ingot. The two side doors of the electric furnace are open. Dolomite shoveled into electric furnace to repair lining.

11.10 a. m.—Mill scale charged for next heat.

11:16 a. m.—Charging launder put in place in mouth of electric furnace.

11:18 a. m.—The new charge of Bessemer metal (30 to 40 seconds overblown) arrives in ladle and slag is poured off. Temperature of empty electric furnace 1300° C.

11:21 a. m.—Pouring of Bessemer steel from ladle into the electric furnace. Temperature of Bessemer metal while being poured into electric furnace, 1500° C.

11:24 a. m.—All Bessemer metal poured into electric furnace. Temperature of empty Bessemer ladle, 1500° C. Electric circuit closed. The electrodes are first regulated by hand, later by automatic electromagnetic regulation (Cuenod).

11:28 a. m.—Charging launder removed. Yellow flames seen, probably from the oil and grease in the mill scale.

11:40 to 11:45 a. m.—One hundred and twenty kw-hours consumed in five minutes. Power-factor, 90 per cent.

11:50 a. m.—Twelve shovels of mill scale added.

12 m.—Temperature inside furnace, 1425° C. Temperature of hottest electrode just outside the furnace, 1050° C.

11:45 a. m. to 12 m.—Three hundred and eighty kw-hours consumed in 15 minutes. Power-factor between 82 per cent and 86 per cent.

12:28 p. m. to 12:33 p. m.—About half the slag skimmed from the bath. Temperature of slag, 1400° C.

12:35 p. m.—Added manganese ore.

12:37 p. m.—Added lime.

12:45 p. m.—Half of the "phosphide slag mixture" charged (see patent of Humbert on page 48 of our January issue). This slag mixture had been previously made up of coke dust and fluorspar.

12:54 p. m.—Rest of "phosphide slag mixture" added.

12:58 p. m.—Ferromanganese and ferrosilicon added.

1:01 p. m.—First test sample taken.

1:08 p. m.—Test made shows that heat is ready for tapping.

1:11 to 1:13 p. m.—Furnace emptied. Temperature of empty furnace, 1500° C.; this temperature dropped 200° C. in 15 minutes, while doors were open to patch up the furnace and make ready for the next heat.

There are altogether four attendants at the furnace: one head melter, one assistant and two workmen. A helping hand is lent by other workmen around the works while tapping and pouring.

At the time of our visit, and during the preceding week, axle steel was made. Rail steel has also been made, also high-manganese steel, ordinary steel castings and manganese-steel castings.

Simply to try what can be done with the electric furnace, a very severe test was made some time ago in which, it might be said, the electric furnace was used as a scavenger. As Mr. Field, the general superintendent of the Illinois Steel Company, explained, they swept up the works to find the worst kind of scrap (plate scrap, rusty nails and everything that was found) and tried to make a fine heat out of it. The electric furnace proved equal to the task.

The specification was to produce steel

C, 0.35 to 0.45; S, 0.04; P, 0.04; Mn. 0.35 to 0.50.

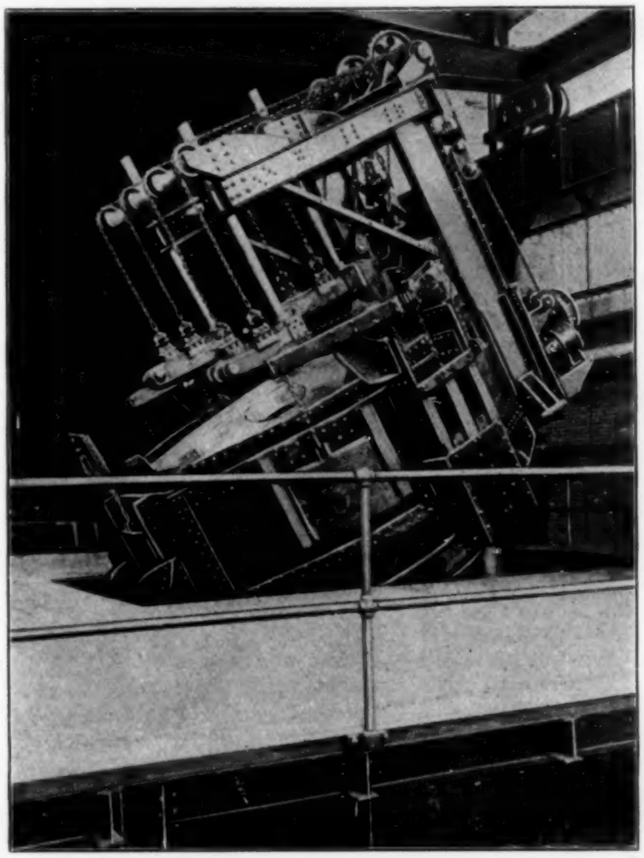
The steel produced analyzed:

C, 0.46; S, 0.037; P, 0.024; Mn, 0.34.

There were charged in this test 9000 lb. hot pig iron, 12,000 rail ends and 9000 stove-plate scrap, "the worst stuff to be found." The product was 31,800 lb. of steel.

The energy consumption during this remarkable test was 14,450 kw-hours. This test was simply made to see what could be achieved with the electric furnace, and proved that it has apparently no ordinary limitations to its refining capabilities.

As to the mechanical tests of the steel now being made by the



HÉROULT FURNACE DIPPED.

Héroult Bessemer-electric process at South Chicago, the following data were given at the mechanical testing plant of the Illinois Steel Company: Elastic limit, 35,000 to 47,000; tensile strength, 60,000 to 70,000; elongation, 25 per cent to 30 per cent; reduction of area, 43 per cent to 60 per cent. As to the difference between this electric steel and acid open-hearth steel it was stated that the same tensile strength is obtained with the electric steel with lower carbon than with open-hearth steel. For example, an 0.10 C electric steel averages the same tensile strength as an 0.15 C to 0.17 C acid open-hearth steel.

As to the general arrangement of the plant it may be said that there was not space available to erect the electric furnace in the immediate neighborhood of the Bessemer plant. The molten Bessemer metal has to be brought from the Bessemer plant to the electric furnace over a distance of a fourth of a mile. Of course, in a new works, built for the proper combination of converter and electric furnace, this would be arranged differently.

In conclusion, we congratulate Dr. Héroult and the United States Steel Corporation on the signal success achieved in their pioneer Bessemer converter-electric furnace combination plant.

which, we have no doubt, is the forerunner of many similar installations, and marks the beginning of a new commercial epoch in practical steel making in America.

The Decomposition of Carbon Monoxide in Presence of Catalytic Agents and in the Blast Furnace.*

By Fritz Zimmermann, Ph.D.

At the last meeting of the American Electrochemical Society in New York, Mr. Edward R. Taylor presented a very interesting paper on the electric smelting of iron ore. In the discussion following this paper, it was pointed out that an attempt should be made to construct electric furnaces in such a way that the escaping gases should consist of practically nothing but N and CO_2 and that, if this would be possible, the energy efficiency, of course, would be very much greater than if they contained a large percentage of CO.

Mr. Lidbury pointed out that there is a ratio between the CO and the CO_2 which is governed by the conditions prevailing—that is, the temperature and the nature of the substances present, which fixes a limit beyond which no further reduction will take place at the expense of the CO.

It might be of interest to give a short compilation of some studies and experiments that have been undertaken by others and myself to study some of the phenomena which are taking place in the blast furnace.

The production of iron in the blast furnace was, until almost the middle of the nineteenth century, purely empirical. Bunsen undertook the first steps to put it on a scientific basis in order to obtain the best possible results. His work on gas analysis enabled him to investigate the composition of the blast furnace gases in different parts of the blast furnace. He found that the carbon dioxide escaping from the furnace always contained more than the double amount of carbon monoxide, naturally causing a big loss of fuel. He was the first one to say that "we cannot really speak of utilizing our fuel properly until someone is able to construct a furnace from which only carbon dioxide will escape besides the nitrogen of the blown-in air."

Assuming that the large amount of carbon monoxide, which usually escapes from the ordinary low furnace, could be forced to reduce more iron ore, Lowthian Bell, the celebrated English metallurgist, began about 1860 to construct furnaces of a very great height. His reason for constructing these furnaces was that the carbon monoxide, instead of passing out into the air, as it always does in low furnaces, should meet more iron oxide, which it could reduce, so that all the carbon monoxide would be utilized. His experiments were a failure, and he was unable to explain why the proportion of CO to CO_2 remained the same as in the old low furnaces.

Le Chatelier, in his "Recherches Experimentales et Theoriques sur les Equilibres Chimiques" (1888), found an explanation. He came to the conclusion that an equilibrium is established between iron, iron oxide, CO and CO_2 which does not depend much upon the temperature. Gas, containing less CO than necessary for this equilibrium, is not able to act reducing on iron oxide; if more iron be present than corresponds to the equilibrium the reversibility of this process will show itself by partly oxidizing the iron until there is again equilibrium.

But the process of reduction is not the only one taking place in the blast furnace. Sometimes we observe a strong precipitation of finely divided carbon in a certain zone of the furnace. This may be so considerable as to clog up the furnace and stop the running of it. For a long time this precipitation of carbon could not be explained until something similar was found in the manufacture of steel.

In continuing certain work done by Berzelius and Saunderson, Caron found that, in passing CO over iron, finely divided carbon was precipitated. He thought it was silicon that caused this precipitation. In his work "Sur la Dissociation de l'Oxyde de Carbone," Saint Claire Deville used a very ingenious apparatus—his cold and warm tube. This consists of a porcelain tube, closed with two double perforated stoppers; through one set of holes a brass tube is placed, which serves for passing cold water through it; through the others, gas may pass. Heating this tube to a strong red heat, he passed pure CO through it, while cold water was flowing through the brass tube; under these conditions, CO was decomposed into CO_2 and carbon. He explains it as a partial decomposition of CO while hot into oxygen and carbon. He assumes that, at the moment the products of dissociation touch the cold tube, they are taken

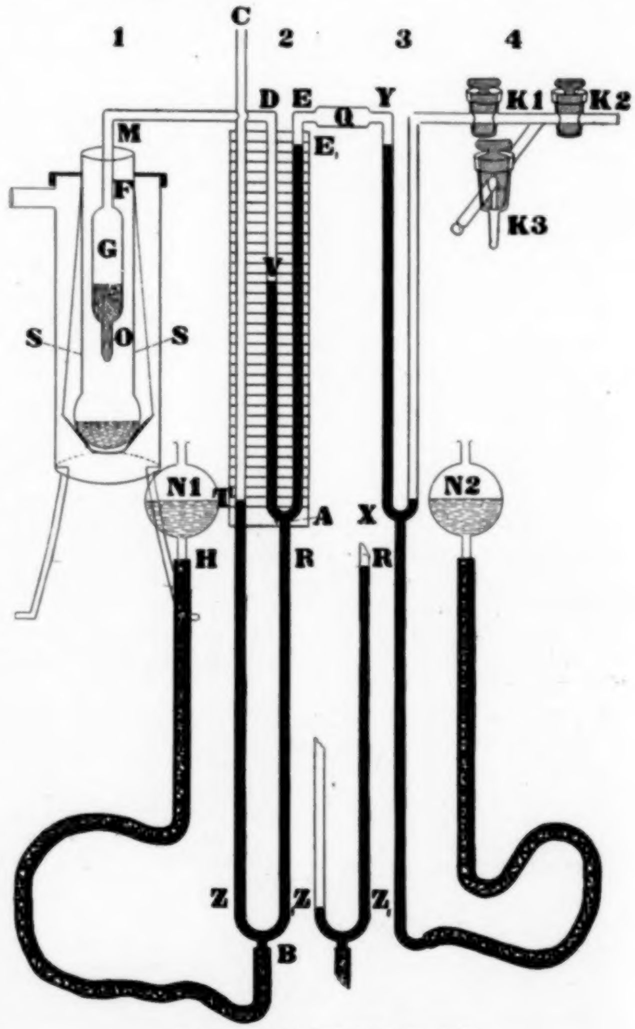


FIG. 1.—ARRANGEMENT OF TEST.

away from the influence of the heat, which otherwise would unite them again. Carbon is precipitated on the cold brass tube, and the free oxygen combines with free CO, forming CO_2.

Stammer got similar results by passing CO over iron oxide. He found that, while the oxide was reduced to metal, iron carbide was formed at the same time, and a precipitate of carbon took place upon the iron.

Gruner, and later Berthelot, worked on similar subjects—the first saying that only the presence of oxide caused a decomposition of CO and that pure iron could not decompose CO, while the latter assumed that a complicated polymerization took place.

Boudouard undertook a series of experiments to study the decomposition of CO in the presence of metallic oxides which, as he assumed, would act as catalytic agents. He used the oxides of nickel, cobalt and iron in the presence of CO in a sealed tube, and analyzed the products of reaction. He found that the speed of reaction and the equilibrium depended upon

*A paper read before the New York section of the American Electrochemical Society on March 16, 1910.

the temperature. At a temperature of about 445 deg. C., in the presence of the metal oxides as catalysers, decomposition should be complete according to the equation of $2\,CO = CO_2 + C$, while, by increasing the temperature, the reverse reaction $C + CO_2 = 2\,CO$ takes place more and more.

To get a better knowledge of these cross reactions, Professor Schenck, then in Marburg and now in Aachen, induced me to make a special study of the character of these reactions. The reaction $2\,CO = CO_2 + C$ is effected with a contraction in volume of 50 per cent, for we start with two molecules CO and come to only one molecule of CO_2, C being precipitated.

By constructing a proper apparatus, this contraction will allow us to follow the speed of reaction.

After building a great many apparatus, I finally came to the following construction, which seemed to answer my purpose in every respect. The apparatus consists of four main parts.

I.—G is a vessel of Jena glass of about 100 c.c. capacity, intended to be filled with a gas and whatever catalyser shall be used; from F on the right side of the apparatus it consists of capillary tubing, so that its capacity may be neglected compared with the 100 c.c. of the heating vessel.

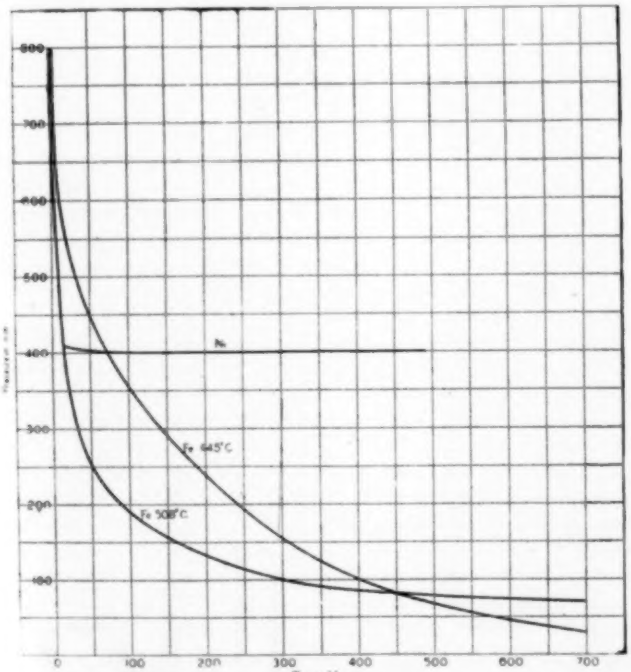


FIG. 2.—DECOMPOSITION OF CO IN THE PRESENCE OF Ni AND Fe.

Before being used G is cleaned well with sodium hydrate and afterwards with chromic and sulphuric acid. Then it is filled with a catalyser through the wide tube O, which afterwards is closed by melting it together in a gas flame; then the capillary tube is molten on the apparatus at the point M. In order to heat G uniformly, it is put in a little furnace consisting of a wide tube S of Jena glass standing on an iron bath, protected by asbestos and sheet iron. In S, different substances, like diphenylamin, mercury, sulphur or sulphide of phosphorus may be boiled.

II.—Consists of two barometers, one put on top of the other; the tube AB is 800 millimeters long, AE and AD are of the same length; BC is a little above 1600 mm; BH_1 is heavy rubber hose, around which heavy linen is sewed in order to prevent it from expanding by the weight of the mercury in the vessel N_1. If N_1 is lowered to Z, the mercury will stand equally high in both tubes BA and BC. By evacuating the apparatus, the mercury in BA will rise to R and the height of mercury Z_1R or the distance between Z and R being the atmospheric pressure. Of course, the mercury cannot rise higher than R. If gas is allowed to flow into the apparatus, it will fill G and the mercury in AB will fall according to the pressure of the gas. If it is less than an atmosphere, N_1 does not need to be changed from its position; if it is more than an atmosphere, N_1 must be lifted up. The distance between R and Z is plus or minus according to the pressure of the gas. After gas has passed into G, N_1 is lifted to T, sealing off the gas entirely. If we evacuate now, the mercury in the tube on the right AE will rise to E; the distance between E_1 and T being the atmospheric pressure. The distance between E_1 and V indicates the absolute pressure of the gas in G; so that the pressure in G can be measured either by the scale distance between E_1 and V or, what is the same, the distance between T plus atmospheric pressure and V.

Q is a vessel to collect drops of mercury that might fly out of AE or XY.

III is another double barometer, the only difference between it and II being that it has no connection with the outside air as BC.

IV.—K_1 and K_2 are ordinary gas cocks; K_3 is a three-way cock leading to vacuum pump, gas developer or gasometer or hood respectively.

In order to get the finely divided catalyser, pumice stone cut to the size of a pea was used. As acid alone did not remove all the iron oxide in the pumice stone, it was reduced first with hydrogen; after this, it was easy to remove all the iron and get an absolutely white product.

In the following experiment, cleaned pumice stone was impregnated with a solution of pure nitrate of nickel—2 grams of nickel to 20 grams of pumice stone being used; the solution was evaporated together with the pumice stone, and afterward the impregnated pumice stone was highly heated on a blast burner until the nitrate was decomposed and only nickel oxide remained. After the apparatus had been thoroughly cleaned and dried, the pumice stone impregnated with nickel oxide was placed in vessel G, which was then evacuated and heated by immersion in boiling sulphur. CO was then passed into the apparatus and the vessel N_1 raised to T. No contraction could be seen.

It might have been that the reaction and contraction had been completed in the first 30 or 40 seconds which were required to flow in the gas and raise the mercury vessel, so that this contraction could not be seen. In order to be sure whether this was the case or not, the apparatus was filled, while cold, with CO, heated to 445 deg. C. and let cool again. The volume was equal to its original. The same result was obtained in heating to 320 deg. C., 360 deg. C. and 508 deg. C. The analysis of the gas contents showed CO_2 only. This proves that the reaction taking place is only a reducing reaction $CO + NiO = CO_2 + Ni$, which, of course, does not show any contraction.

I also observed no contraction after using cobalt oxide or iron oxide. The only reaction taking place in each case was a partial reduction of the metallic oxide. This proves that the oxides of nickel, cobalt and iron are no catalytic agents able to bring about the decomposition of CO to $CO_2 + C$, as had been claimed.

In the next experiments, pure metals were used instead of the metallic oxides; the metals being obtained in a finely divided state by reducing the metallic oxides precipitated on the pumice stone. Nickel was used first; after using every possible precaution, CO was allowed to pass into the vessel at 445 deg. C. Reaction took place immediately, causing strong contraction, which came to a standstill after heating for about an hour. A contraction of 80 per cent of the pressure, observed in the beginning, had taken place.

The experiment was repeated several times, practically with the same result.

At 360 deg C. contraction, which could be measured, was slower than at 445 deg. C. and amounted to 91 per cent.

At 310 deg. C. the temperature of boiling diphenylamin, the reaction was slower and came to standstill after seven hours; the decomposition being 96%. Cobalt gave similar results.

In order to see whether the equation $2CO = CO_2 + C$ and with it a contraction of 50 per cent takes place, cobalt as catalyser was used. The vessel was filled, while cold, with CO, then heated and afterward allowed to cool in cold water to the same temperature as before. The contraction was exactly 50 per cent, showing that CO really had been decomposed into $CO_2 + C$. The gas analysis showed practically nothing but CO_2.

With nickel, the same experiment could not be made, on account of nickel tetracarbonyl being formed. In order to see whether the presence of CO_2 would change the reaction, a mixture of CO and CO_2 was passed into the apparatus. The contraction was 50 per cent of the CO contents, so that the CO_2 did not seem to have any influence on the reaction.

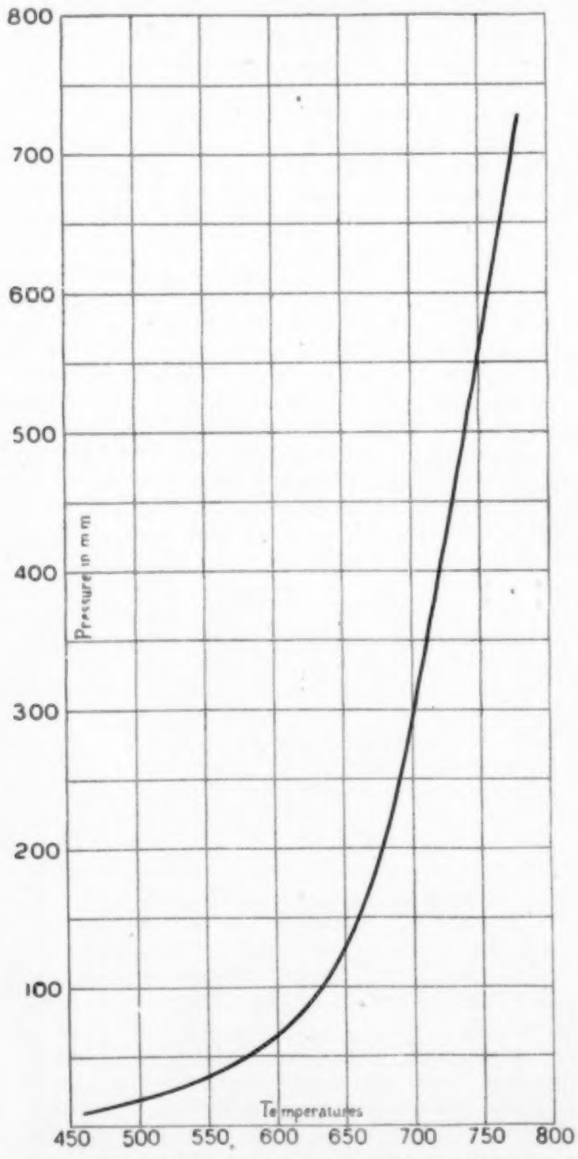


FIG. 3.—PRESSURE CURVE $CO + CO_2$ AT DIFFERENT TEMP. IN THE PRESENCE OF Fe ACCORDING TO SCHENCK.

In the following experiments, iron as a catalyser was used. At 360 deg. C. the reaction was very similar to that of nickel and cobalt, but at 445 deg. C. a very curious phenomenon took place. The decomposition did not only go to 50 per cent, but the contraction continued and came almost to a vacuum. For instance, starting with 787 mm pressure, after heating nine hours, we came to 32 mm. In another series of experiments at 508 deg. C., very rapid contraction took place, but the final pressure was a little higher than at 445 deg.

The explanation of this phenomenon with iron is as follows: While the decomposition, in the presence of nickel, cobalt, and iron at low temperatures, occurs according to the equation $2CO = CO_2 + C$, the iron, at temperatures of 445 deg. C. and 508 deg. C. enters itself into the reaction. It is oxidized and reduces the CO_2 according to the equation $Fe + CO_2 = FeO + CO$. The CO, formed in this way in the presence of fresh metallic iron, is decomposed again. These reactions continue until nearly all the gas has disappeared. The CO which was present at the beginning is then almost all decomposed, its carbon precipitated, and its oxygen bound to iron. This proves that carbon monoxide under these conditions being converted into CO_2 is really an oxidizing agent for iron.

The dual influence of the iron, viz.: that it first acts as a catalyser to bring about the reaction $2CO = CO_2 + C$, and then secondarily enters itself into the reaction as soon as the CO_2 concentration is high enough, may have a great influence on the efficiency of an iron-reducing furnace. As soon as the CO_2 concentration exceeds a certain limit, the gas will not only be unable to reduce FeO to metal, but will even reoxidize iron which may have already been reduced, and, in this way, bring about the contrary of what is intended, viz.: oxidizing iron to oxide instead of reducing oxide to metal.

I might add that, in order to see to which point CO can act oxidizing, Professor Schenck and Dr. Heller undertook a great number of determinations. They used two methods:

First.—They allowed CO, at constant temperatures, to act on finely divided iron and determined the pressure at which the reaction came to a finish.

Their second method was to mix ferrous oxide with carbon and to heat the same to constant temperatures. The reduction took place with development of CO and CO_2. The development of gas stops after the pressure of the total equation is reached. For both methods, they used a quartz tube, which was connected with a glass manometer.

The results of both methods were the same, and they were able to prove that CO is only able to act oxidizing up to a temperature of 780 deg. C. Above this temperature, CO can only act reducing.

By these experiments, they proved that metallic iron only enters into the equation of CO, CO_2 and C below 780 deg. C., while above this temperature it does not react any more with CO.

This reaction $2CO = CO_2 + C$, in the presence of metallic iron at low temperatures, also explains the clogging up of the furnaces in which CO is decomposed in the presence of metallic iron. This will, for instance, take place if a furnace, in which iron has been reduced at higher temperatures, suddenly cools off and CO comes in contact with this metallic iron.

This investigation, of course, is by no means complete as to all the reactions that are taking place in the blast furnace. These experiments were simply undertaken to study the decomposition of the carbon monoxide in the presence of metals. The other reactions that are taking place in the blast furnace, the equation between carbon, carbon monoxide and carbon dioxide at different temperatures and the action of these with different iron oxides have been investigated very completely, both theoretically and practically by Boudouard, Schenck, Baur, and Glaessner.

Indigo White.—Electrolysis is used in a French process of Henri Chaumat, of Paris, to reduce indigotine to indigo white. The process is carried out in a bath of alkali carbonate protected from the air. The anode is carbon and the cathode indigotine. The latter is in form of a powder, which may be agglomerated with powdered graphite or other good conductor of electricity. Under the influence of the electric current hydrogen is formed at the cathode reducing the indigotine and producing indigo white which dissolves in the alkali simultaneously produced, forming a dyeing solution.

Production of Aluminium as a Laboratory Experiment.

By B. NEUMANN AND H. OLSEN.

It is peculiar that the methods of operation used in an industry which produces almost 2000 tons of metal per year are so little known that the production of this metal on a laboratory scale meets with difficulties. The two articles published in this journal during the past year on the production of aluminium in the laboratory confirm this remark.

The first detailed laboratory experiments have been published by Haber and Geipert,[1] who used a carbon crucible and employed a current of about 400 amp. M. deKay Thompson[2] could not, however, obtain satisfactory results when employing the method described by the above authors. He used a cell of graphite plates, and a subdivided anode and employed currents up to 1000 amp. The arrangement of Tucker,[3] who used a conical graphite crucible, can hardly be considered an advance over former apparatus.

We have also tried to make aluminium on a laboratory scale and have endeavored to imitate as much as possible the conditions of large-scale practice. The results of our experiments are given in the following article.

Process Used in Practice.

A photograph of an aluminium cell has been published only once, as far as we know, by J. W. Richards[4]; the cell shown is evidently a cell of Charles M. Hall, as used some years ago. The illustration shows 20 round anodes in two parallel rows in a high iron box. Quite detailed notes illustrated by sectional diagrams were given later by Winteler.[5] The cells described by Winteler are also rectangular and are also provided with double rows of carbon electrodes. More recently circular cells have been introduced, the anodes being distributed over the whole surface.

The aluminium cells are simple reinforced wrought-iron boxes on the bottom of which there is a series of carbon plates. The bottom plate acts as cathode at the start of electrolysis; the aluminium which is set free collects on the carbon plate and then acts itself as cathode. The reason of covering the bottom with carbon is that at higher temperatures aluminium alloys with iron; further, in the beginning, when the mixture of cryolite and alumina is molten by means of a carbon resistor, the local heat effect may easily be excessive, so that the iron bottom would be burned through.

The cell is made so wide that the walls do not come into direct contact with the molten bath, but are completely covered with a layer of solidified charge. The size of the cell depends on the current. For a current of 8000 amp the cells have a length of 1500 mm (4 ft. 11 in.), a width of 1000 mm (3 ft. 3 in.) and a height of 400 mm to 500 mm (1 ft. 4 in. to 1 ft. 8 in).

In each cell there are 6 to 12 carbon anodes, which are suspended from insulated supports.

Formerly carbon blocks of about 100 sq. cm (15.5 sq. in.) cross-section and 1 m (3.28 ft.) length were used and current densities of 3 amp to 5 amp per square centimeter. The distance of the anodes from the walls was 15 cm (6 in.). The distance of the different anodes from each other was 10 cm (4 in.). If the distance is less the anodes are liable to rapid destruction and carbon particles fall into the molten bath and foul it.

This disadvantage is now avoided by using very short electrodes with a much larger cross-section. Such electrodes are 40 cm (16 in.) high and have a cross-section of 35 cm x 35 cm (14 in. x 14 in.). The current density used is also lower, namely, 0.8 amp to 1 amp per square centimeter. Overheating of the bath is thereby avoided, but the bath remains quite fluid.

With the new short electrodes a relatively smaller voltage is lost in the electrodes. A disadvantage is the greater amount of anode scrap, but this is practically of no importance, since it is worked over again.

The method of supporting the cells is of great importance. Formerly the cells were placed free on insulated supports, the intention being to cool the walls and the bottom by contact with the air. An adjustable current of air was passed below the bottom. This method, of course, involved a great loss of heat and this had to be made up by the use of higher current densities. In modern practice the cells are not free, but enclosed, although some free space is left to permit the passage of an adjustable air current for cooling the bottom and sides.

The most suitable composition of the charge is a mixture of 80 per cent to 90 per cent of cryolite and 10 per cent to 20 per cent of alumina. Formerly some per cent of sodium chloride were added to reduce the melting point. The purity of the raw materials used is of great importance; any iron or silicon present are especially deleterious since they pass into the final product and deteriorate the physical and electrical properties of the aluminium. It is well known that it is impractical to refine aluminium afterward.

The voltage of a cell is about 6 volts, but depends considerably on the distance between anode and cathode. A low voltage is an indication of a correct composition of the charge. If there is not sufficient alumina in the charge the voltage rises.

The mixture is fused by inserting between the carbon bottom and each anode a little rod of carbon and heating it to white incandescence. When the charge is molten the carbon resistors are removed and the anodes are lowered into the bath. The temperature of the bath should be such that the color is about dark cherry red. On the surfaces of the bath crusts are constantly formed, which must be broken from time to time.

Former Experiments.

Haber and *Geipert* use a hollow carbon block as cathode and furnace, a movable carbon anode being suspended from above. The inside diameter of the circular hole was 11.3 cm at the bottom and 13.8 cm at the top; the depth was 7 cm. The diameter of the electrodes was 6.6 cm, the cross-section, therefore, 34.2 sq. cm. The use of a turned carbon block is not very advantageous for this purpose, because cracking of the block cannot be avoided. In two experiments artificial cryolite was used; in the third experiment natural cryolite. The charge consisted of 1000 grams of cryolite and 200 to 300 grams of alumina.

Haber and Geipert fused the mass by means of an arc and then started the electrolysis with 7 volts and 400 amp. The use of the arc for melting the charge is unsuitable because quite a quantity of cryolite and aluminium fluoride evaporate and because the arc causes the formation of aluminium carbide.

The experimenters did not pay special attention to the anodic current density, although this is of greater importance than the cathodic current density. Since the average current was 310 amp to 336 amp, the anodic current density was about 10 amp per square centimeter. That is much too high, and this is the reason why the anode was always consumed so as to form a sharp point.

The statement that the color was bright red shows that the temperature was too high. This is easily understood if 300 amp and 8 volts were used for 1200 grams to 1300 grams of charge. The amp-hour efficiency was 54.3 per cent, 44.84 per cent and 43.56 per cent.

M. deKay Thompson tried to reproduce exactly the experiments of Haber and Geipert, but the amp-hour efficiency obtained by him was only 38 per cent; the temperature of the bath was found to be 1100° C.; the voltage 10.5 to 12.5. The charge in the crucible soon became darkened and contained graphite. Then the anode effect occurred.

Another experiment was made in a box of graphite plates

[1] *Zeit. f. Electrochemie*, 1902, pages 1 and 26.
[2] *Electrochemical and Metallurgical Industry*, 1909, page 19.
[3] *Electrochemical and Metallurgical Industry*, 1909, page 315.
[4] *Electrochemical Industry*, 1903, Vol. 1, page 160.
[5] *Aluminium Industrie*, 1903 (published by Vieweg & Sohn, Braunschweig).

1.9 cm thick; the area of the bottom was 17.8 cm x 17.8 cm; the anode consisted of four graphite plates in the form of a grid 12.5 cm in height, breadth and length. The current used was, first, 500 amp, and later 900 amp to 1000 amp. The temperature of the bath was approximately 1000° C. The amp-hour efficiency was 49 per cent. The voltage was between 9 and 10.

Thompson was the first who mentioned the phenomenon of the anode effect, which occurred always after working for one-quarter of an hour or for half an hour, even when he repeated Haber's experiments. The current density used by him with the divided anode was much too high, namely, about 10 amp per square centimeter.

Tucker used a conical crucible turned from a 12.5-cm diameter graphite rod. The diameter of the conical hole was 12 cm at the top and 3 cm at the bottom and a graphite electrode, with a diameter of 3.15 cm, was the anode. He also fused the charge by means of the arc. He employed a mixture of cryolite with 15 per cent alumina, and used a current of 325 amp at 10 volts to 12 volts. The anodic current density was 28

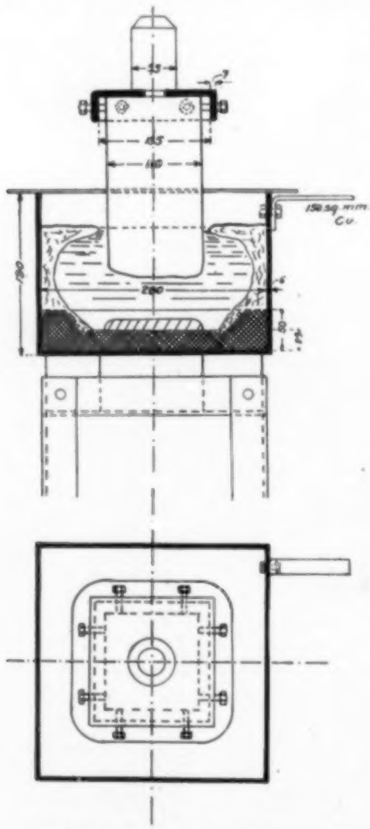


FIG. 1.—FURNACE CONSTRUCTION.

amp per square centimeter. The anode was quickly destroyed. This method seems unsuitable.

Experiments of the Authors.

1. **Furnace Construction, Electrodes.**—In order to imitate as much as possible large-scale practice, we used similar furnaces. All our furnaces were made of wrought-iron sheets and had a bottom plate of carbon. A copper bar was screwed to the iron box to make the connection to the circuit. The bottom carbon plate was firmly pressed against the bottom by means of screws. The various furnace designs employed differed only by form and size.

We used in our experiments a direct-current machine which gave 300 amp at 14 volts. But it could be easily so connected as to give 150 amp at 28 volts. This was quite an advantage for our experiments. The furnace dimensions were so chosen that the whole current of the machine could pass directly through the cell without use of series resistances. The most suitable design for this purpose was a simple square box of 5-mm wrought-iron sheets, which were welded at the edges, the bottom surface being 28 cm x 28 cm and the height 19 cm. An Acheson graphite plate was fixed to the bottom. Its thickness was increased later to 2.5 cm. This was found to be the best thickness.

The anodes were carbon blocks of smaller or greater size up to 14 cm x 14 cm cross-section. As shown in the illustrations, they are held by a wrought-iron head with the aid of copper sheets by means of eight screws.

The furnace box was placed on an iron frame and could be cooled at the bottom and at the sides by means of air or when necessary could be heated from the outside by means of burners. In the first experiments the fusion of the large quantity of powdered substance was quite difficult, so that the possibility of heating from the outside was at times quite an advantage. After we had gained some experience, it was no longer necessary to heat from the outside.

In order to melt the charge a hard carbon resistor of 6-cm length and 1.6-cm diameter was inserted between anode and bottom plate and heated by the current to white incandescence. In this way the mixed charge surrounding the carbon resistor was slowly fused. In the beginning the melting of the charge was sometimes not realized, because the anodes, which consisted of blocks of graphite, conducted too much heat away. This difficulty disappeared when we used hard-carbon blocks, which were furnished to us from the Plania Werke, in Ratibor. The graphite anodes are also easily destroyed during electrolysis, and the particles which dropped off spoiled the bath. It might probably be advantageous to make the bottom plate also of hard carbon instead of graphite.

We have also used smaller furnaces of 20 cm. diameter and less. The melting of the mass was quite successfully accomplished. But the small furnaces have the disadvantage that the charge is fused right to the walls of the iron box; during electrolysis as soon as the resistance near the bottom increases on account of undissolved alumina the current no longer passes to the bottom, but to the side walls.

2. **Observations During Operation.**—When melting a mixture of cryolite and alumina, care is to be taken to have the carbon always covered by the mixture, since otherwise the carbon would burn through at the place where it is uncovered. A charge which has already once been fused is more easily melted than a fresh powdered mixture. A charge of 12 kg requires about 3½ hours for melting. In this case a layer about 2 cm. thick around the walls remains unmolten.

In order to start electrolysis the anode is quickly raised, the carbon resistor is removed from the bath by means of an iron tongue and the anode is then suspended again into the bath. If the anode has the correct temperature, electrolysis starts at once. Graphite electrodes which are good conductors are cooled so easily that when the electrode is raised out of the bath it becomes covered with a thin layer of solidified charge and when it is again suspended in the bath only a small amount of current passes through the cell; the whole bath may then freeze. With hard carbons the danger is less.

When in our experiments the anode had accidentally cooled off too much (while taking it out of the bath in order to remove the carbon resistor) and when it was observed that the current decreased after the anode had again been suspended in the bath, we changed the connections of our machine, so as to run at the double voltage (28 volts); this overcame the trouble. The connections of the machine were then again changed and the electrolytic process took place absolutely quietly.

We have observed several times that in melting a fresh charge the carbon resistor was surrounded by a tube of a mixture rich in alumina which would not melt. The cause is probably to be found in the moisture in the charge. When thoroughly preheating the alumina the phenomenon did not occur.

The electrolysis was always very quiet in the large furnaces.

The distance of the anode from the bottom plate was in the beginning 6 cm; later somewhat less on account of the reduction in volume of the charge. The anodes were regulated about every 30 minutes. During electrolysis (as is also the case in practice) a hard crust formed on the bath, which had to be broken for regulating the electrodes or for making additions to the charge.

With this relatively small cell the uniform solution of the alumina in the bath offered sometimes difficulties. Part of the charge added later often directly forms crusts and, therefore, does not get into the bath at all, so that the level of the bath falls. Sometimes the added charge also falls to the bottom of the bath without dissolving quickly enough, so that the alumina accumulates near the bottom and thickens the bath and increases the resistance. The amount of the addition of alumina was calculated on the basis of an average amp-hour efficiency of 50 per cent. One hundred amp-hours produce theoretically 33.7 grams of aluminium, so that with 50 per cent amp-hour efficiency only 16.85 grams are obtained, corresponding to the consumption of 31.8 grams of alumina. But as hardly all the alumina is dissolved, we used practically 40 grams of alumina per 100 amp-hours in mixture with the same amount of cryolite. When the electrolysis proceeded properly, the calculated amount of this mixture was added every thirty minutes. If there was trouble, either alumina alone or cryolite alone was added, according to the circumstances. An addition of aluminium fluoride was mostly unnecessary.

Whether the composition of the bath is correct, is well indicated by observing the temperature of the bath and the voltage. When the electrolysis has been going on for some time the aluminium deposited acts as cathode. In the beginning of our experiments we have melted several times a certain amount of aluminium on the supposition that this would facilitate the first deposition of aluminium, but we could not find any considerable advantage.

If some undissolved alumina deposits once on the bottom, all kinds of disturbances are experienced. The heavy layer presses the aluminium upwards, and the contact between the aluminium and the bottom plate gets poorer. Or the metal no longer covers the whole surface, but only a part, and therefore grows toward the anode, whereby an overheating effect is produced. By stirring the bath and ladling out the aluminium the difficulties can be overcome.

The occurrence of the anode effect mentioned by M. deKay Thompson has been observed by us also occasionally. The anode effect is due to the fact that the anode is no longer wetted by the bath. It seems that the anode is surrounded by a gas layer, small arcs passing over between anode and bath. On account of this transition resistance the voltage increases by several volts. Fluorine is then set free at the anode.

According to our observations the anode effect occurs if the anodic current density is too high, say, more than 4 amp per square centimeter. This phenomenon also occurs when large anodes are irregularly consumed. The composition of the charge, however, also plays a part. The less the content of fluorine in the bath the more often does the anode effect occur. By quickly opening and closing the circuit, this trouble can be overcome.

Occasionally an ill-smelling gray layer of molten metal is found on the bottom; in contact with water this metal evolves a gas which consists mainly of hydrogen. We could not prove the presence of aluminium carbide. The gray color is caused by a metallic mist of very finely divided aluminium.

In the following we give the details of two different experiments; in one case trouble was experienced, while the other experiment was absolutely quiet.

A.

12 kgs. of charge, consisting of 10 per cent alumina and 90 per cent cryolite; cross-section of anode 80 sq. cm.

Melting, 3 hours 50 minutes.			
8.45 } 12.35 }	300 amperes	7 volts	
Electrolysis			
12.40	150 "	13.5 "	900° C.
12.45	200 "	10.4 "	
1.15	200 "	10.0 "	
1.45	185 "	10.5 "	
1.55	200 "	10.0 "	
2.00	215 "	9.6 "	
2.05	225 "	9.2 "	950° C.
2.20	250 "	8.8 "	
2.35	260 "	8.6 "	
2.45	270 "	8.4 "	
3.00	280 "	8.1 "	
3.20	240 "	9.0 "	
3.35	270 "	8.3 "	
3.40	280 "	8.0 "	
3.45 to 58	Anode effect remedied.		
4.00	230 amperes	9.0 "	
4.10	200 "	9.8 "	
4.20	180 "	10.6 "	

Eighty grams charge were added at 1.45, 160 grams charge at 2.05, 200 grams charge at 3.00, 30 grams alumina were added at 3.20 and 100 grams cryolite at 3.40.

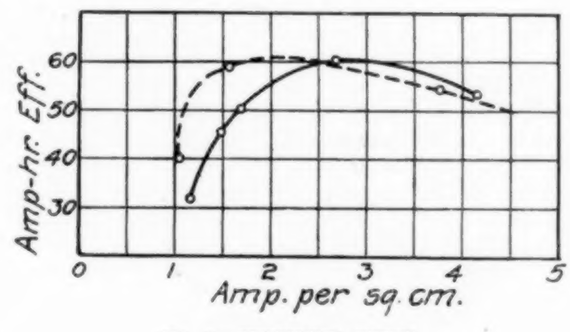


FIG. 2.—EFFICIENCY CURVES.

The experiment was then stopped on account of the anode effect. The anode was finally so much corroded that the anodic current density had increased to an amount which produced the anode effect.

The time of the electrolysis was three hours and forty minutes, the average current 214.5 amp, so that 778.5 amp-hours had been consumed, which should have yielded theoretically 265 grams of aluminium. The output was in reality 161 grams of aluminium, so that the amp-hour efficiency was 60.8 per cent. The current density was 2.68 amp per square centimeter.

B.

12 kg. of charge, consisting of 10 per cent of alumina, 10 per cent of sodium chloride, and 80 per cent of cryolite.

Anode surface 11 by 11 cm = 121 sq. cm.

Melting, 3 hours 40 minutes.		
11.00 } 2.40 }	300 amperes	7 volts
Electrolysis	60 grams aluminium added.	
2.40	200 amperes	14.4 "
3.00	200 "	9.0 "
3.30	200 "	9.0 "
4.00	200 "	9.0 "
4.30	200 "	9.0 "
4.50	200 "	9.0 "
5.10	160 "	9.2 "
5.30	160 "	9.2 "
5.45	160 "	9.2 "
6.10	150 "	9.4 "
6.30	150 "	9.4 "
7.00	150 "	9.4 "

During this experiment 100 grams of the mixture of alumina and cryolite were added every 30 minutes. The experiment was interrupted because the current from the central station was disconnected. Seven hundred and eighty-five amp-hours had been consumed. The theoretical output should have been 266 grams. while 156 grams of aluminium were obtained in fact. The amp-hour efficiency was therefore 58.8 per cent. In this experiment 14.6 per cent of sodium chloride evaporated.

In another experiment the loss of fluorine was determined. There were in the beginning 50.26 per cent of fluorine in the bath, while after one hour's electrolysis the bath contained only 47.47 per cent, so that the loss was 2.79 per cent.

3. **Results of Experiments.**—In the following we give the results of a number of tests made with different anodic current densities:

Charge.	Anode surface.	Ampere hours.	Time of electrolysis.	Current density in amperes per sq. cm.	Ampere hour efficiency.
10% alumina and 90% cryolite	169 cm.	750	3 hrs. 50 min.	1.17	31.8%
	144	690	3 " 15 "	1.48	45.5
	121	875	4 " 15 "	1.70	49.8
	81	545	3 " 10 "	2.15	49.6
	80	778	3 " 40 "	2.68	60.8
	50.3	1010	4 " 50 "	4.15	53.0
10% alumina, 80% cryolite, 10% NaCl	169	685	3 " 45 "	1.08	40.0
	121	785	4 " 10 "	1.57	58.8
	50.3	336	2 " 5 "	3.12	53.9
	50.3	373	2 " — "	3.72	54.2

If these results are plotted graphically it will be seen that the amp-hour efficiency is a maximum for an anodic current density of 2 amp per square centimeter. On the other hand, the results are very poor with a current density of 1 amp per square centimeter. But this does not agree with the results from operation on a large scale. It should not be forgotten, however, that in experiments with electric furnaces the conditions in the laboratory furnace are very different from the conditions in the large commercial furnace, and that in the latter the losses from conduction and radiation can be made very much smaller. An anode which is too large, such as is used in our experiments, with a current density of 1 amp per square centimeter, carries off so much heat that the bath cannot be maintained at the proper temperature. The above results are, therefore valid only for our design of furnace and are not valid in general. The best amp-hour efficiency which we obtained was 70.4 per cent with a current density of 2 amp per square centimeter.

From the diagram of Fig. 2, it is seen that an addition of 10 per cent of sodium chloride exerts a beneficial influence only with small current densities, while with higher current densities the bath which contains no sodium chloride gives better results.

Some experience is required to carry out successfully the experiments. In the beginning we experienced difficulties especially in melting the charge. In such cases it is to be recommended to cover the side walls of the iron box, and perhaps also the upper portion of the anode, with asbestos board to reduce the radiation loss and to heat the bottom of the box with gas burners. Much time is saved in this way. It is also to be recommended not to select at once too big an anode for the first experiments.

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Chilling or Heating Action of Furnace Electrodes Versus Least Electrode Loss.

BY CARL HERING.

In determining the proper proportions of electrodes for furnaces, the choice may sometimes arise between allowing the loss in the electrode to be slightly greater than the least possible, or allowing the electrode to slightly chill or heat the product in the furnace; either may be adopted at a sacrifice of the other. The difference is due to the variations of the conductivities with the temperature.

The purpose of the present article is to discuss this choice from the standpoint of the designer and constructor of furnaces, and to analyze in a general way the underlying principles, believing that the results of such an analysis may be of some use as a guide in determining what the best proportions are for any given conditions, either by showing how to take account of these factors or by showing that they may be neglected.

In the writer's earlier papers* it was shown that when the variations of the conductivities with temperature can be neglected, the conditions under which there will be no chilling of the furnace product by the electrode are identical with those for the least possible loss of energy in the electrodes. And that the conditions for the latter also correspond with those for the avoidance of excessive temperatures (higher than those in the furnace) within the furnace walls.

While any further corrections in these useful general results, due to the variations of the conductivities with the temperature, are probably too small to require attention in practice, and that, therefore, the writer's simplified solutions will probably suffice in most cases, yet the question has been raised as to the effect of these variations and much stress has been laid on them by others, much more, in the writer's opinion, than is warranted by their small importance. But as it was not known what the effects were, or how large they were, it left an uncomfortable uncertainty.

The purpose of the present article is to endeavor to show the nature of these, more with a view of clarifying the situation than to lay any stress on their importance; on the contrary, it is believed that it will rather tend to show that we may be content to neglect the quantitative effects of these troublesome temperature variations in ordinary practice; or when greater accuracy is required, it will show in what direction the allowances for these corrections should be made.

Dr. A. E. Kennelly, in a very able and interesting paper* was the first, and so far the only one, to demonstrate that these variations give rise to only slight differences between the law for the minimum loss and that for no flow of heat to or from the furnace—that is, the two laws are then no longer quite identical. This will also be seen to be made evident by following out the new method of analysis used in the writer's article in the March issue of this journal, page 128, on "Properties and Behavior of Furnace Electrodes," to which the reader is referred for a further description of the method to be used below.

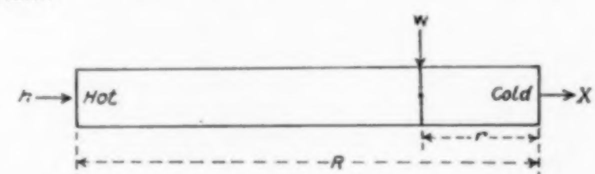


FIG. 1.—CENTER OF GRAVITY OF ELECTRODE.

In the adjoining Fig. 1, which represents an electrode, let it be assumed that the material, carbon, for instance, has a falling temperature coefficient, in which case the colder half will have the greater resistance; hence, the greater half of the watts will be generated in this half. The center of gravity of this uneven distribution of the generated watts will, therefore, be to the right of the middle, as shown by the point of the arrow. It may, therefore, be assumed for the present purpose that all the watts w are generated in the section drawn through this center of gravity at the arrow marked w.

It was shown in the article in the March number, just referred to, that the number of watts necessary to keep any heat h from flowing from the furnace—that is, to prevent all chilling action by the electrode, increases as this center of gravity is nearer to the cold end; if it were quite near, the number of watts would be extremely high, hence the loss very great.

It hardly requires an algebraic analysis to show that in such

* This journal, October, 1909, Vol. VII, p. 442, and revised and enlarged in *Trans. Am. Electrochem. Soc.*, Vol. XVI, p. 265.

* "On the Modifications in Hering's Laws of Furnace Electrodes Introduced by Including Variations in Electrical and Thermal Resistivity." Proceedings Am. Inst. Elec. Eng., March, p. 267.

a case if the section be increased somewhat it would reduce the number of watts generated by that same current, and in the same proportion, hence it would reduce that part of the total loss which is due to the resistance. This increase in section would, however, cause some heat to leave the furnace—that is, it would cause some chilling action. But as the latter would be small, while the reduction in the former would be relatively large, it follows that the total loss would be diminished.

Hence, without any intricate algebraic analyses, it is evident that with carbon or any other electrode material having a decreasing resistivity for an increase of temperature, the total loss could be diminished, if desired, by making the section somewhat larger than that required for no flow of furnace heat, and allowing it then to chill the furnace somewhat. The designer has his choice between the two evils. An increase of size is an evil in this case because carbon electrodes are in general already undesirably large in section before this increase is made.

In making this choice it must be remembered that a chilling action of the electrode signifies that the capacity of the furnace is reduced thereby, and it must be considered whether the gain in a smaller loss is worth this reduction in the capacity of the furnace; in general, it probably will not be. One of the chief advantages in proportioning electrodes as recommended in the writer's earlier papers, is that the capacity of the furnace may thereby be raised to its full extent.

The physical meaning of this action of carbon is that it is more economical in power to send some of the energy in the form of electricity through the whole length of the electrode into the furnace and then let it flow back again and out at the cold end, its original entrance, in the form of heat. In other words, such an electrode allows electrical energy to flow more freely in one direction than it allows the same energy in the form of heat to flow back in the other direction. It is an action somewhat analogous to a leaky valve.

With electrode materials like iron, on the other hand, which have a rising resistivity, a similar argument shows that the total loss could be reduced also, but in this case the center of gravity is nearer the hot end, and the section must therefore evidently be decreased. Hence, instead of chilling the furnace product by this change, the flow of heat would now be from the electrode into the furnace—that is, with iron electrodes it is possible not only to reduce the former minimum loss, but, in addition, to actually send more heat into the furnace than it did before when the loss was greater. It is no longer a choice between two evils, but a double gain. The attending objectionable feature, however, is that somewhere within the walls there will then be generated a higher temperature than in the furnace itself.

While it is evident that by making such changes in the section the total loss may be decreased, it is also evident, when this change of section is greatly exaggerated, that the total loss will again increase and become much greater than it was originally. This means that there is a certain section at which the loss is a minimum.

The amount of this change of section to reduce the loss to a minimum, of course, will depend upon how far the center of gravity is from the middle; the farther it is, the more will be the possible reduction in the loss. This means that the greater the change of the resistivity with the temperature, the greater will be the reduction of power loss which becomes possible by operating at a minimum loss instead of with no chilling action and with no high temperatures within the walls.

As stated above, this possible change of section therefore depends on the shifting of this center of gravity; if there is none, the conditions of minimum loss will correspond with those for no flow of heat, as in the simplest case discussed in the writer's earlier papers. If the position of this center of gravity is given by n so that $n = R/r$, in which R is the total thermal resistance and r that from the center of gravity to the cold end; and if a represents the change of cross-section necessary to change from the condition of no flow at the hot end when the section is S, to that of minimum loss when the section is s—that is, if $a = s/S$; then it can be shown that for a minimum loss $a = \sqrt{n - 1}$. The proof of this law for the minimum is given below.

To illustrate this with examples, suppose $n = 4$, that is, $r = 0.25\,R$, which is believed to be a very exaggerated case, probably far beyond any that would occur in practice. It means that the center of gravity has been moved one-half the distance from the center to the cold end, if the thermal conductivity is uniform, or, if not, then to such a distance that the thermal conductivities are in that proportion. Then $a = 1.73$, that is, the new section would be almost twice as large.

Let W equal the loss for the original section when there was no flow of furnace heat. From the formula (11) given below, the minimum loss will now be $0.866\,W$, or only 13.4 per cent less than before. The generated watts w are now, from (2), equal to $0.577\,W$, or a little over half as much as before. The loss of heat h from the furnace now is, from (10), equal to just half of w, or $0.289\,W$—that is, over a quarter as much as the total loss was originally. As a check, the total loss now is the sum of w and h; namely, $(0.577 + 0.289)\,W = 0.866\,W$ as before.

Hence, even under greatly exaggerated conditions, the gain in power loss by making this change would be only 13.4 per cent, and this involves almost doubling the size of the electrode and a loss of furnace heat equal to over one-quarter of the original total loss, which would be quite likely to chill the furnace appreciably, thereby reducing its effective size. Under ordinary conditions it would therefore probably not be worth while to make this correction due to this change of resistivity.

Let it now be assumed that the resistivity rises and to such an extreme extent as to bring the center of gravity half way to the hot end. The results, calculated in the same way, now are $n = 4/3$, $a = 0.577$, $w = 1.732\,W$, $h = -0.866\,W$, and total loss $0.866\,W$. Hence, in this case the saving of power would again be 13.4 per cent, the size of the electrode would be reduced to nearly one-half, and the generated watts would be nearly doubled, but just half of them would now flow into the furnace, thereby contributing heat to it instead of chilling it as before. This would be a gain in all features, except for the fact that a higher temperature than that in the furnace would be generated within the walls. Whether this is a disadvantage depends chiefly on the temperature conditions. In a low-temperature furnace for tempering castings, for instance, it might perhaps be taken advantage of.

In making the above corrections due to the temperature coefficients, the change of section would bring about slight changes in the temperature gradients, and it will be found that these in turn react to again reduce the advantages of the change somewhat. Hence, the exact gains would be even less than the small ones given by these formulas.

This correction involves both conductivities; hence, a material like graphite, which has a slightly falling electrical resistivity and a rapidly falling thermal conductivity, would presumably act in this respect like a material with a rising resistivity—that is, like the metals and unlike carbon.

The general conclusions of the present investigation, therefore, are that, in general, these corrections are too small to be considered in practice, and that the engineer need consider them only in so far that when the material has a falling resistivity (like carbon) he had better make the section a little larger rather than smaller, and when the material has a rising resistivity he may feel safe to make the section a little smaller than the simple formulas require. This lack of importance of these temperature corrections is indicated in the writer's earlier papers by the flatness of the minimum curve, as was described at that time.

PROOF OF THE LAW.

Let W = watts generated in the electrode when there is no flow of heat through the hot end.

w = watts generated in the electrode when the total loss is least.

h = actual flow of heat through the hot end when the total loss is least.

X = total minimum loss.

a = the ratio of the section for minimum loss to the section for no flow through hot end; that is, the proportion in which the section for no flow at furnace must be increased or diminished to give the section for minimum loss. The length is assumed constant.

R = thermal resistance of whole electrode.

r = thermal resistance of the part from the center of gravity of the watts to the cold end.

n = the ratio of these two thermal resistances, that is R/r.

T = total temperature drop in the electrode.

Let all the values be known for the condition that there shall be no flow of heat through the hot end. Hence, W is known. These are determined by the laws given in the writer's previous papers, when the constants used are those determined by the method therein described,* in which they are based on the conditions of no flow at the furnace end. Now let it be required to find how much larger or smaller the section should be made in order to reduce the loss to a minimum. This increase or decrease of section is represented by the ratio a.

It is evident that when the section is now changed, the current and, of course, the temperature drop being the same, there will always be some actual flow of heat through the hot end; this is represented by h; when the section is increased the flow will be from the furnace, that is, h will be positive; when the section is decreased, it will be from the electrode into the furnace, that is, h will be negative. Attention is here called to the fact that in the present discussion h represents the actual flow of heat and not that which would flow if there were no electric current.

The total minimum loss is now the sum of that generated electrically in the electrode and that flowing from the furnace; hence

$$X = w + h \qquad (1)$$

in which w and h are to be determined.

The value of w will, of course, vary inversely with the section; hence,

$$w = W/a \qquad (2)$$

But the value of h is not so easily determined. The electrical analogy again indicates the solution. If an electric current h enters one end of a conductor, as in Fig. 1, and another, w, enters somewhere between the ends, the two joining and flowing out of the other end together; then if the condition is that in all cases the drop of potential T between the two ends is always the same, the relations between these two currents are readily found as follows:

The total drop of potential T will be the sum of that in the first part, where h is flowing alone, plus that in the second part where h and w flow together. Hence, if R is the total resistance and r is that of the second part, then

$$T = h\,(R - r) + (h + w)\,r = hR + wr \qquad (3)$$

This applies equally well to thermal currents and in this equation the letters for the corresponding thermal quantities have been used; it, therefore, represents the thermal relations.

In the original electrode, in which there was no flow of furnace heat, h, this quantity h is zero; hence, if r' is the thermal resistance of that part of that original electrode between the center of gravity of the generated watts and the cold end, then

$$T = Wr' \qquad (4)$$

* More in detail in a paper on "A New Method of Measuring Mean Thermal and Electrical Conductivities of Furnace Electrodes." *Trans. Am. Electrochem. Soc.*, Vol. XVI, p. 317. Abstracted in this journal, Vol. VII, p. 514.

As the difference of temperature T between the two ends is the same for both, these two expressions may be equated, and if at the same time they are simplified by substituting

$$n = R/r \qquad (5)$$

and

$$r' = ra \qquad (6)$$

the final result reduces to

$$h = W\,(a - 1/a)/n \qquad (7)$$

Hence formulas (2) and (7) will give the values of the watts w generated electrically and the flow of heat h out of or into the furnace through the hot end, when the value of a is known for which the total loss will be least. It is evident that some such value of a must exist, because if the section be either increased or decreased greatly it is easily seen that the total loss must increase; hence, if it increases in either case there must be some value for which it is least.

To find this, the calculus must be resorted to, but the solution is extremely simple. The total loss X is always the sum of w and h (remembering that h here is the actual flow while the electric current is flowing, and not the flow when there is no current). Hence,

$$X = w + h = W/a + W\,(a - 1/a)\,n = W/n\,\left(a + \frac{n-1}{a}\right) \qquad (8)$$

Differentiating this and placing the first differential coefficient dX/da equal to zero, gives, after reduction, the very simple relation

$$a = \sqrt{n - 1} \qquad (9)$$

which is that value of a which will make X a minimum.

Hence the change a in cross-section necessary to change over from the condition of no flow through the hot end to that of minimum total loss is very readily found from the known value of n.

Knowing this value of a, all the other quantities are easily calculated. The new generated watts, w, are found from the simple formula (2). The flow of furnace heat h may be found from formula (7), but by combining it with (9) and (2) it reduces to the simpler forms

$$h = \frac{W}{a}\left(\frac{n-2}{n}\right) = w\,\left(\frac{n-2}{n}\right) \qquad (10)$$

which latter also shows the relation of h to w. When this value becomes negative it means that heat is flowing from the electrode into the furnace—that is, there is a high temperature point in the electrode.

The total minimum loss is the sum of w and h, and is given in formula (8), but it may now be reduced to the more simple form.

$$X = \frac{2\,aW}{n} \qquad (11)$$

It might be of interest to state that when $n = 2$, that is, when the center of gravity is in the middle, the formulas all give the same results as in the writer's original paper, as, of course, they should.

Conclusion.—Incidentally, the present investigation is a good illustration of the recommendations of certain distinguished scientists, namely, that it is best to solve a new problem first under the simplest possible conditions, leaving the refinements to a second or third approximation, if indeed these refinements are necessary at all. This is the practice which the writer has endeavored to follow in his solution of the electrode problems and it has led to simple results which are thought to be amply sufficient for all practical purposes.

PHILADELPHIA, March 9, 1910.

Near Alloys.

In the issue of Feb. 22 of *Metallurgie* Prof. K. FRIEDRICH, of the Institute of Technology of Breslau, Germany, makes the following interesting and suggestive remarks:

Thermal research work of the last decades has proved that the melting and freezing process of an alloy does not occur at a certain fixed temperature, but takes place within a wider

range of temperature. This at least is the rule. Exceptions are the case of the end constituents of the alloys, viz., the pure metals, the chemical compounds, and finally certain solutions to which belong the eutectics and those compositions for which the curves of crystal mixtures show a minimum or maximum.

Within this freezing or melting interval, the extension of which depends on the ratio of the quantities and the nature of the constituent parts, the alloy consists of a molten and a solid portion. If the former is in excess we have a fused bath in which crystals are floating, while if the latter is in excess we have crystals impregnated with liquid drops. If we select a proper ratio of the constituents we can produce a substance which is plastic and can be kneaded. Now let us add materials of a higher melting point, work them into our dough-like substance, let us mix the mass more intimately, perhaps by means of a certain pressure, let us cool it, and we will get a product which is not yet known in practice, namely, an alloy closely interspersed with foreign substances, without having had before a homogeneous solution.

Professor Friedrich mentions the following two examples from his laboratory practice:

He makes an alloy of 90 parts by weight of tin and 10 parts by weight of copper, fuses the two substances together by heating to about 500° C., and cools to about 220° C. In this neighborhood is the eutectic point. By proper regulation of the temperature (which in this case is not difficult, since the melting interval extends to about 450° C.) he obtains a dough-like mass. He now adds the foreign substance, which may be particles of light-blue cobalt silicate, the size and quantity of which is left entirely to his judgment. He kneads it all at a constant temperature, finally using pressure, so as to get it into the desired form. He then cools it, grinds and polishes it, and thus obtains a product which shows blue interstices in a white metallic field in a fairly uniform distribution.

In his second example Professor Friedrich begins with a mixture consisting of 98 parts by weight of lead and two parts by weight of antimony. First, he forms the alloy and then cools it until the eutectic temperature—about 250° C.—is reached. The mass is dough-like. He now adds iron filings; 10 parts by weight can easily be introduced. This is followed by mixing and pressing. The result is a kind of hard lead.

Are the products thus obtained true alloys? "Alloys in the fused state are essentially solutions of two or more metals or metalloids in each other."[1] They are produced from their constituents by fusing them together, therefore, by formation of a liquid solution. That is the rule. Where other modes of procedure have reached practical importance they are based at least on the tendency of the materials concerned to enter into solution. We may call attention to the process of diffusion of carbon into solid iron low in carbon if this iron is in direct contact with carbon or carbonaceous substances.

With our products there is no necessity that the substances employed are soluble in each other. Our products are, therefore, not true alloys. They are alloy-like structures, metallic compositions, near-alloys or whatever we may call them. At all events they are but mechanical mixtures. As far as known, such mixtures have not yet found any application in practice. They have been produced, however, before, especially by Spring,[2] who pressed powdered solid metals together under high pressure. This does not result in genuine alloys, as was said of Spring's experiments, but simply in mixtures as proved recently by Masing.[3]

Professor Friedrich's method differs from the method of Spring in that he does not start from solid metals, but from a dough-like substance. This means an advantage over Spring's process. The use of the substance in the dough-like condition permits the production of intimately mixed mixtures without employing very high pressures. The added particles can be rather coarse grained.

[1]Ledebur, Die Legierungen. 1906, p. 1.
[2]Bull. Acad. Belg. since 1878; especially Vol. 49 (1880), p. 323.
[3]Zeit. f. anorgan. Chemie, 1909, Vol. 62, p. 265 to 309.

Of course, the dough-like condition is limited to a certain, and often brief, range of temperature. It is, therefore, necessary not only to heat the mixing and pressing devices, but to regulate the temperature exactly. With small quantities the latter condition is easy to fulfill by employing electric heating. But even with larger quantities the temperature may be maintained constant in practice without any great difficulty. Professor Friedrich draws attention to the Pattison process, where in a proportionately large kettle a silver-lead bath can be kept for one or two hours at a temperature of about 300° C. within 10° or 15°.

As to the properties of these new near-alloys it is, on the one hand, a disadvantage that they are only mechanical mixtures, but, on the other hand, it is an advantage that we are almost perfectly at liberty to select the material to be added. The only limitation is that the added substance remains solid and unaffected at the temperature of the mixture.

To go into details Professor Friedrich admits that in regard to tenacity, toughness, resistance against chemical influences, and good thermal and electric conductivity his near-alloys can hardly compete with genuine alloys even if a strong pressure has been employed in their preparation. For it would be exceedingly difficult to produce a mechanical mixture with such an intimate intermingling of its constituents as in an alloy that has been produced from homogeneous liquid solution.

The greatest disadvantage is that it is impossible to cast the near-alloys. On this account they cannot be used for many purposes.

On the other hand, with our near-alloys, we have the possibility of making metal-like substances perhaps of an especially low thermal and electric conductivity, since we can add to the fundamental alloy oxides, silicates, and, in general, poor conductors.

Further, the hardness of the near-alloys can be adjusted to much greater nicety than has been possible heretofore. Quartz, corundum, carborundum can be embedded in alloys. In a lead-antimony alloy iron may be embedded and its hardness adjusted exactly to that of the material of the axle.

The greatest field of usefulness of these near-alloys would be, according to Professor Friedrich, the production of "terrazzo"-like mixtures with a metallic base, as well as articles for general usage and for decorative purposes with peculiar color effects. As substances to be added there are at our disposal precious metals, artificial and natural minerals, especially precious stones, further enamels and glasses. Besides the tin-copper alloy mentioned above, silver-copper alloys would be also suitable as a starting material. For a composition of 90 parts by weight of silver and 10 parts by weight of copper the range of freezing temperature extends from 778° C. to 890° C.

Finally, the process permits perhaps the replacement of more expensive alloy constituents by cheaper ones. Professor Friedrich mentions the substitution of iron for antimony in hard lead, although in this respect the impossibility of casting the near-alloy is especially troublesome. But there might be left, or could be found, a small market anyway for this new kind of hard lead.

Altogether it is evident that near-alloys cannot enter into serious competition with genuine alloys. They are no full-fledged substitutes for the same, and can only be considered as of an inferior grade. But where they extend the present applications of alloys they may find use.

The Magnetic Properties of Electrolytic Iron and Some Commercial Steels.

By Charles F. Burgess and James Aston.

In connection with tests of the various properties of iron alloys made from electrolytic iron,* measurements were made of the magnetic quality. The results on certain of the binary

* Investigation of electrolytic iron and iron alloys made in the Chemical Engineering Laboratories of the University of Wisconsin under a grant from the Carnegie Institution of Washington.

series have been presented in several articles in previous issues of Metallurgical and Chemical Engineering. In these discussions it was pointed out that the primary material in the preparation of the alloys was electrolytic iron of high purity (99.9 + iron); and a common standard of comparison throughout all the tests was a bar forged from an ingot of electrolytic iron.

In this paper we are presenting data of tests made upon various samples of electrolytic iron, together with those upon the original anode material, indicating thus the effect of refining upon the magnetic quality. We have also embodied for comparison the results upon commercial samples of different degrees of purity.

Magnetic testing is not on such a basis at present that data of different investigators, at different periods of time and by different methods of testing, are strictly comparable. Even in the absolute ballistic method results are often markedly inconsistent; and comparisons of heterogeneous collections of data are likely to be misleading. All of our data, while open to the common objection to intercomparison, were obtained by the same operator upon the same apparatus, with every precaution taken, before any series of tests were made, to have consistent checking to a standard; the results, therefore, may be considered strictly comparable among themselves.

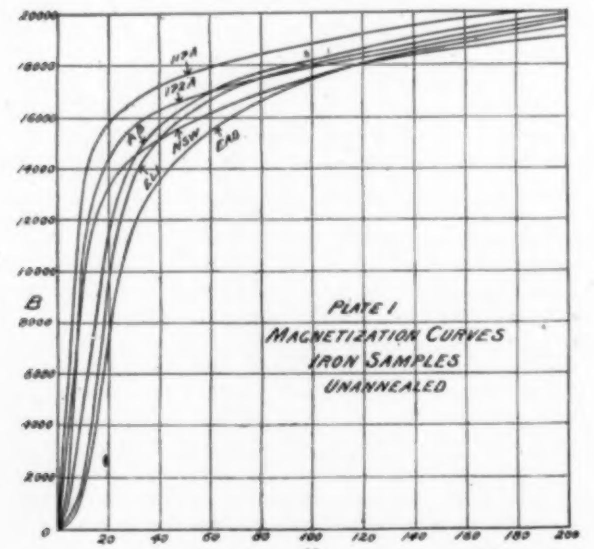


FIG. 1.—MAGNETIZATION CURVES. IRON SAMPLES. UNANNEALED.

Electrolytic Iron Tests.

Tests under four different heat treatments have been made upon the sample noted in the following table:

Bar.	Character.	C.	P.	Si.	S.	Mn.	Fe.
NSW	Swedish anode, forged..	0.260	0.007	0.109	0.007	0.021	99 596
EAD	Single refined as deposited, not forged......	0.019	0.013	0.002	0.006	0	99.960
117A	Electrolytic, melted and forged	0.047	0.016	0.062	0.005	0	99.870
AB	Electrolytic, melted and forged	0.120	0.014	0.001	0.009	0	99.856
ELI	Electrolytic, melted and forged	0.012	0.041	0.008	0.019	Tr.	99.920
172A	Electrolytic, melted and forged	....	....	....	....	....	.....

NSW is forged from one of the anode bars as used in the single refining tanks, and was bought for high-grade Swedish iron. The analysis indicates a somewhat high carbon content, but the material has the desirable quality of being very low in phosphorus, which is a troublesome element in the refining operation, as will be seen by examination of the phosphorus content of the refined bars. The indications are that all of the phosphorus had been carried over to the cathode, and the percentage content in the product increased because of the loss of iron in the slimes. However, it must be noted here that analyses of the double refined iron showed a phosphorus content of only 0.003 per cent. The analyses above show also the difficulty of preventing the absorption of carbon by the charges, due to the reducing action of the iron upon the carbon monoxide furnace atmosphere.

Bar EAD was cut from a heavy single refined cathode sheet without melting or forging (in fact, without any heating whatever) and is thus representative of the electrodeposited material. Bars 117A, AB, ELI, and 172A are made of electrolytic iron melted into ingots and forged into rods. For 172A, double refined material was used.

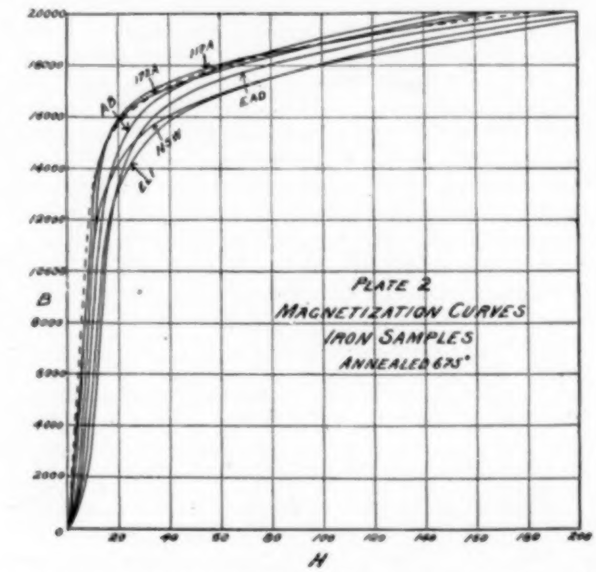


FIG. 2.—MAGNETIZATION CURVES. IRON SAMPLES. ANNEALED 675°.

The results of the tests are indicated in Tables I and II and in the curves plotted in Plates 1, 2, 3 and 4. In the unannealed condition, the forged electrolytic iron bars (117A, AB, ELI, and 172A) represent a considerable variation in relative quality. This cannot be ascribed to the difference in purity, as will be noted on comparison of the analyses. The differences are very likely due largely to the molecular condition of the samples, as a result of lack of uniformity in the forging temperature and to strains set up in working. Bars 117A and 172A are especially good, the former in particular being so uniformly good in the unannealed state and throughout the entire length of the curve that it was chosen as the standard comparison curve for all our tests.

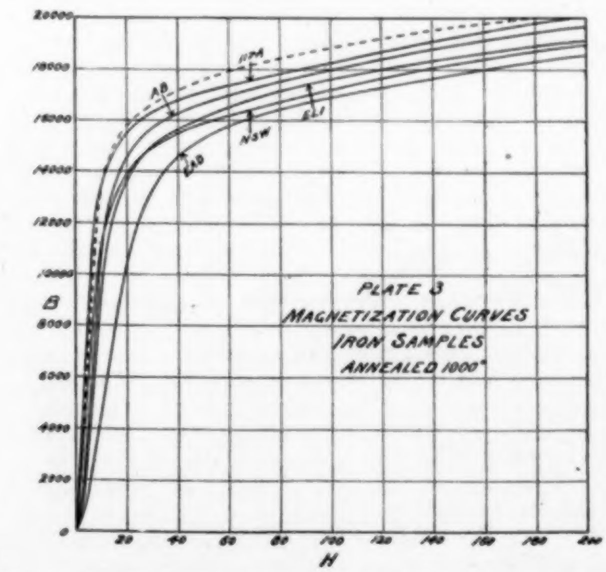


FIG. 3.—MAGNETIZATION CURVES. IRON SAMPLES. ANNEALED 1000°.

The effect of successive heat treatments is seen by inspection

of the curves and tables. For comparison, the curve for 117A as unannealed is indicated by a dotted line. A marked improvement throughout the entire range of the curves is the result of heating to 675° and slowly cooling, due no doubt to the removal of all forging strains and the opportunity afforded for the grain size of the material to become normal. The improvement is most pronounced in the poorer samples of the unannealed tests (AB and ELI) and it is very slight in bar 117A, indicating, perhaps, that the forging treatment left it in practically its best molecular condition.

A second heating has been accompanied by an improvement of the quality in the lower ranges of the magnetizing force,

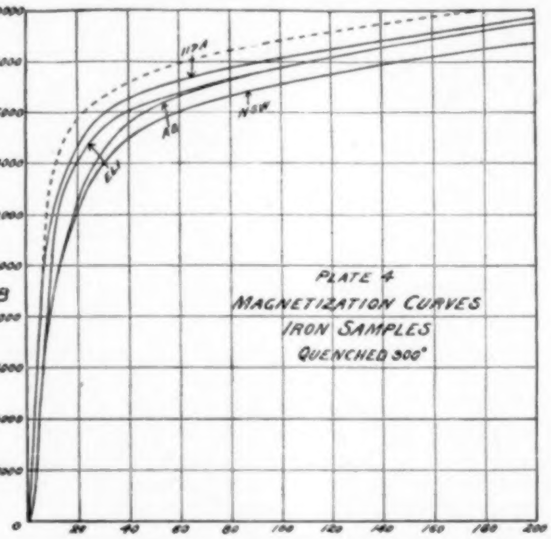


FIG. 4.—MAGNETIZATION CURVES. IRON SAMPLES. QUENCHED 900°.

but except for these ranges, the densities fall below those for the lower annealing temperature.

Quenching from a temperature of 900° C. has been accompanied by a deterioration of the quality for all magnetizing forces. This effect is most marked for the lower valves of H, but, all in all, it is very slight, indicating in a way the purity of the material, since, although the temperature was sufficiently high, the absence of carbon had prevented any hardening. This is more clearly brought out in Table II, where the coercive force and retentivity are indicated for the various treatments. The coercive force, indicative of the magnetic hardness, which in turn varies with the physical hardness, has become less under the successive heatings.

ment the superiority of this Swedish anode is less marked, even at low values of H; and in all cases, at higher values of the magnetizing forces (H above 20) the electrolytic curves reach higher maxima of density. Further annealing at 1000° C. has only served to increase the general effect just mentioned.

The influence of the carbon is most interestingly evident in

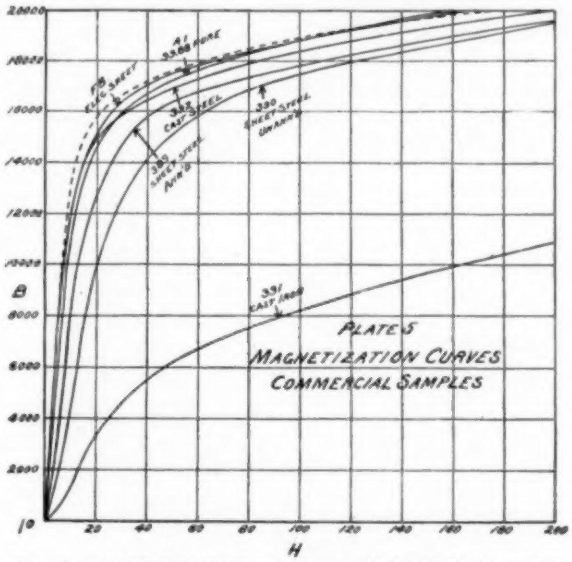


FIG. 5.—MAGNETIZATION CURVES. COMMERCIAL SAMPLES.

the following table, where the coercive forces are given after annealing at 1000° C. and again after quenching at 900°.

Bar.	Per cent, C.	Coercive Force— Annealed, 1000°.	Quenched, 900°.
ELI	0.012	6.0	5.5
117A	0.047	3.1	2.5
AB	0.120	5.5	5.5
NSW	0.260	3.9	5.0

In this group of curves, one of the most interesting is EAD, made, as mentioned previously, from electrolytic iron as deposited, without melting or forging. In the original condition it may be classed as rather poor material, falling well below the other curves in the lower ranges of magnetizing force, and having the high coercive force of 18.5. After the first annealing, however, it has become very good material, taking a place in the midst of the others. The coercive force has fallen off to 9.3, or one-half of its former value, and the value of B for H = 20 has almost doubled, from 7300 to 13,250. The effect may be ascribed to the driving off of the hydrogen occluded in the electrodeposition, and perhaps the allied alteration in crystalline structure.

TABLE I.—DATA OF MAGNETIC TESTS.

Bar. Composition.	H = 10 Unannealed.	Annealed, 675°.	Annealed, 1000°.	Quenched, 900°.	H = 20 Unannealed.	Annealed, 675°.	Annealed, 1000°.	Quenched, 900°.	H = 50 Unannealed.	Annealed, 675°.	Annealed, 1000°.	Quenched, 900°.	H = 100 Unannealed.	Annealed, 675°.	Annealed, 1000°.	Quenched, 900°.
NSW—Anode	9,500	10,000	10,850	8,400	13,200	14,200	13,900	12,050	15,700	16,500	15,850	15,550	17,450	18,000	17,200	17,100
EAD—As deposited	1,650	4,000	4,700	....	7,300	13,250	10,300	....	14,550	17,050	15,300	....	17,450	18,500	16,900	....
117A—Electro-forged	13,100	10,000	13,350	11,800	15,750	15,950	15,450	14,600	17,600	17,700	17,050	16,950	18,850	18,850	18,200	18,150
AB—Electro-forged	4,900	7,700	10,900	8,400	11,450	14,650	14,600	12,400	16,400	17,500	16,650	16,200	18,150	19,050	17,600	17,750
ELI—Electro-forged	2,000	6,000	9,300	10,000	9,550	13,050	13,600	14,050	16,000	16,400	16,100	16,450	18,000	18,050	17,600	17,750
172A—Electro-forged	10,400	12,500	8,000	....	14,300	15,900	12,700	....	16,700	17,450	16,100	....	17,900	18,850	17,600	....
AI—High purity	10,800	....	....	....	14,500	....	....	....	17,200	....	....	....	18,800	....	....	....
277—Commerc'y pure	11,100	....	....	....	14,500	....	....	....	17,100	....	....	....	18,600	....	....	....
258—Norway	11,700	....	....	....	14,800	....	....	....	16,500	....	....	....	18,100	....	....	....
131—Bessemer	7,900	....	....	....	13,100	....	....	....	16,400	....	....	....	18,200	....	....	....
FB—Sheet	....	11,900	....	....	....	15,200	....	....	....	17,500	....	....	....	18,800	....	....
390,389—Sheet	4,200	8,200	....	....	9,800	12,700	....	....	15,100	16,300	....	....	17,400	17,800	....	....
392—Cast steel	....	11,700	....	....	....	14,900	....	....	....	16,800	....	....	....	18,300	....	....
OH—Open hearth	7,800	....	....	....	12,200	....	....	....	15,700	....	....	....	17,700	....	....	....
CRU—Crucible	3,600	....	....	....	8,100	....	....	....	13,700	....	....	....	16,600	....	....	....
248—Tool	400	....	....	....	1,600	....	....	....	10,100	....	....	....	14,900	....	....	....
391—Cast iron	1,300	....	....	....	3,200	....	....	....	6,200	....	....	....	8,200	....	....	....

The effect of the refining is indicated by comparison of the curves for bar NSW, the anode material, with those discussed above. Unannealed, and at lower magnetizing forces, it is very good magnetically; in fact, it excels two (AB and ELI) of the four refined bars. 117A and 172A are better, however, throughout the whole range of tests. After the first heat treat-

Commercial Samples.

Included in Tables I and II and plotted in Plates 5 and 6 are the results of tests on commercial samples of types representing

varying degrees of purity. The descriptions of the materials are as follows:

Bar.	Character.
A. I.	High purity commercial iron, made by basic open-hearth process. Purity, 99.884; C, 0.030. Sample cut from rolled bar and tested without heat treatment.
277.	Commercially pure iron—composition and heat treatment unknown.
258.	Norway iron—composition and heat treatment unknown.
131.	Bessemer steel—composition and heat treatment unknown.
F. B.	Sheet steel—made and treated especially for electrical purposes.
390.	Second quality sheet steel from large electrical manufacturer—not annealed.
389.	Same as 390, but annealed.
392.	Cast steel used by large electrical manufacturer.
O. H.	Open-hearth cast steel for electrical work.
CRU.	Crucible cast steel from same source as O. H.
248.	Tool steel.
391.	Cast iron.

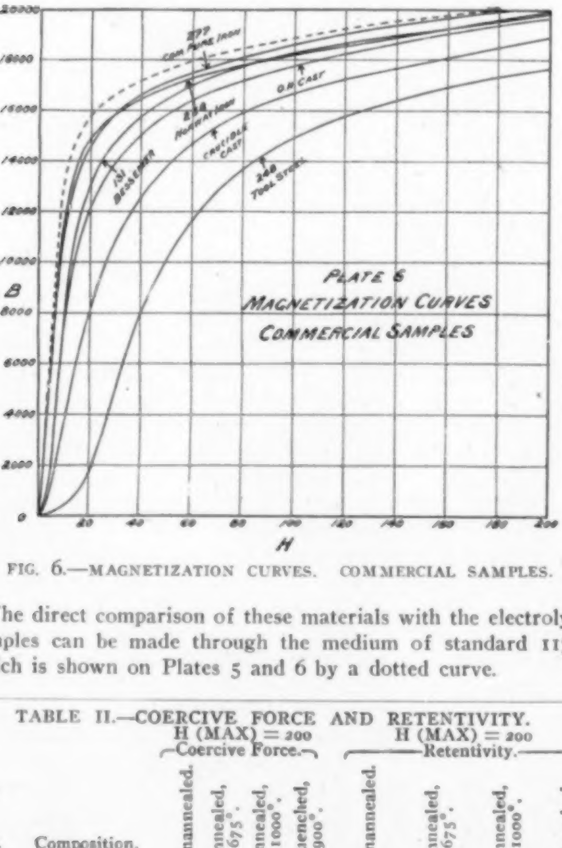


FIG. 6.—MAGNETIZATION CURVES. COMMERCIAL SAMPLES.

The direct comparison of these materials with the electrolytic samples can be made through the medium of standard 117A, which is shown on Plates 5 and 6 by a dotted curve.

TABLE II.—COERCIVE FORCE AND RETENTIVITY.

Bar. Composition.	H (MAX) = 200 Coercive Force.				H (MAX) = 200 Retentivity.			
	Unannealed.	Annealed, 675°.	Annealed, 1000°.	Quenched, 900°.	Unannealed.	Annealed, 675°.	Annealed, 1000°.	Quenched, 900°.
NSW—Anode	5.5	4.8	3.9	5.0	11,400	12,700	9,000	8,500
EAD—As deposited	18.5	9.3	6.2	..	11,200	12,900	4,900	....
117A—Electro-forged	5.5	6.2	3.1	2.5	12,300	13,800	10,000	8,000
AB—Electro-forged	10.0	8.1	5.5	5.5	12,000	13,800	10,700	8,500
ELI—Electro-forged	7.9	9.5	6.0	5.5	13,900	12,000	10,900	13,400
172A—Electro-forged	7.0	5.0	5.8	..	12,400	12,300	9,400	....
AI—High purity	4.0	..	..	..	9,600	....	....	....
277—Com. pure	3.8	..	..	..	10,100	....	....	....
258—Norway	4.2	..	..	..	11,350	....	....	....
131—Bessemer	7.1	..	..	..	12,250	....	....	....
F.B.—Sheet	..	3.0	..	..	....	9,800	....	....
390, 389—Sheet	9.3	5.2	..	..	9,650	8,900	....	....
392—Cast steel	..	3.6	..	..	....	9,700	....	....
OH—Open hearth	7.1	..	..	..	11,400	....	....	....
CRU—Crucible	11.5	..	..	..	9,200	....	....	....
248—Tool	29.1	..	..	..	10,450	....	....	....
391—Cast iron	12.3	..	..	..	4,800	....	....	....

But little comment is necessary in this comparison. The effect of chemical purity of the material is indicated by the high quality of those materials of higher purity. The result of judicious annealing is shown in curves 389 and 390, a low-grade material markedly improved by the heat treatment.

Hysteresis tests on several of these materials are given below, all being carried to a uniform maximum flux density of B = 12,000 per square centimeter.

Bar.	Loop Area.	Relative Area.	H (Max.).
117A	8.65	1.	8.2
NSW	8.14	0.94	13.0
389	11.36	1.31	16.1
390	20.56	2.38	28.0
FB	7.25	0.84	10.3
AI	9.18	1.06	12.0

Bars 117A and NSW were tested after quenching, and this should be borne in mind in making comparisons.

A few general conclusions may be pointed out as a result of the tests.

The refining of commercial steels results in improvement of the magnetic qualities.

The amounts of impurities met with in commercial practice do not result in a serious deterioration of the quality.

Judicious heat and mechanical treatment has an importance equal to that of chemical composition, and proper annealing undoubtedly results in marked improvement in the magnetic quality.

Chemical Engineering Laboratories,
University of Wisconsin.

A Rotary Extractor for Precious Metals from Solutions.*

By W. D'Arcy Lloyd and Ernest T. Rand.

From time to time attempts have been made to precipitate gold and silver from their cyanide solutions while the precipitating agent was in motion, with more or less success. For example, zinc shavings have frequently been subjected to mechanical motion while in contact with the gold and silver cyanide solutions, and in most cases as far as actual precipitation of the precious metals was concerned, some success has been achieved, but mechanical difficulties have developed due to the method of applying motion by attrition, etc.

The main idea underlying all the attempts to perform the operation of precipitation with the precipitating agent in motion, is to avoid the fouling of the zinc, which is so painfully evident in the first compartments of all extractor boxes after a three days' run from time of dressing. It is well known that after thorough washing and redressing, the zinc will go on precipitating as briskly as ever until fouling starts again. The natural inference from this is that if the zinc could be kept continuously in motion, thus preventing fouling, the highest efficiency would be maintained. Having this in view, we have evolved the machine of which we endeavor to give some idea.

The precipitating agent used was zinc in the form of shavings and clippings, the latter being cut from sheet zinc and approximately ¼ in. to ⅝ in. square. The machine is a rotating one, with a water-tight casing of comparatively light steel plate, the casing being fitted with cross-sectional plates to divide it into compartments. In the machine with which the experiments were carried out, there were four of these compartments, but there is reason to think that the result required would be attained with three, the third being one-third larger than the first and second.

In the center of these division plates are securely fixed bearings, in which a hollow shaft rotates. Two circular disks, in each compartment distant from each other almost the full length of the compartment, are securely bolted to flanged collars, which in turn are fixed to the shaft. The shaft, with these discs and other attachments, form the rotor.

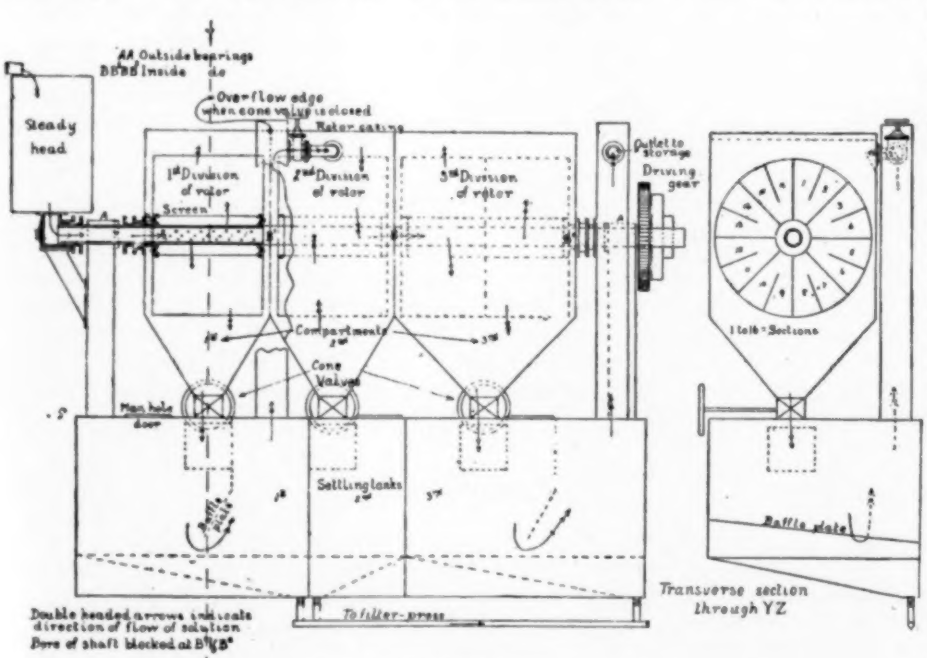
The rotor, besides being divided into compartments in length,

*A paper read before the Chemical, Metallurgical and Mining Society of South Africa. From the December, 1909, issue of the journal of the Society. A short abstract of this paper appeared in our last issue, page 152.

is subdivided radially, in appearance much as a transverse section of an orange. There are sixteen radial divisions, which number was arrived at experimentally, the pressure of solution during rotation of a smaller number tending to press the zinc against the wall of the divisions, leaving a space between the zinc and the next wall. The use of the larger number of radial divisions obviated this tendency. These radial divisions are removable, and are lightly and strongly constructed of perforated (3/16-in. holes) steel plate.

Between and attached to the discs a suitable framework is fixed to contain the sections. There are many simple methods of retaining the sections when in position. Each section has a door of the same material as that of which the section is constructed, so that each is independent of its neighbor.

Around the shaft, and fixed securely to the flanged collars to which the rotor discs are fixed, is a strong screen of ⅛-in. mesh, leaving a space of about 2 in. between itself and the shaft, to prevent any fine material entering the shaft. The shaft is hollow, the bore being of ample size to allow of the free flow of the solution. The parts of the shaft enclosed by the flanged collars are perforated by inch holes to allow of the free egress and ingress of solution. At the required position the bore of the shaft is tightly closed to regulate the flow of the solution to wherever it is required.



ROTARY EXTRACTOR.

At the inlet end of the rotor for the solution is a small tank to act as a steady head, the top of this tank extending about 18 in. above the top of the rotor casing. At the outlet end of the casing, the pipe for carrying away the effluent is so placed that a constant level of the solution is maintained within the casing, which insures that the rotor will be completely submerged.

The bottom of each of the casing compartments is made in the form of a cone, and to this is fixed a valve which connects the cone with a settling tank, whose total capacity is equal to one and a half times that of the casing; this is divided into compartments to correspond with the number of those in the casing. All the solution passes from the casing into the settling tank from both the first and third compartments. The solution passes from the second compartment into the third compartment of the casing along the hollow shaft.

The compartments in the settling tanks have a sloping bottom to one point in each, at which point a valve and pipe connection is made communicating with one main pipe, which leads to a filter press. To the first compartment of the settling tank a stand-pipe of ample capacity is fixed, and stands outside and close to the rotor casing and projects a few inches above it. A pipe from this standpipe delivers into the second compartment of the rotor casing. A similar standpipe is supplied to the third compartment of the settling tank, and the outlet pipe from this delivers to the sump, the position of this pipe determining the level of the solution in the rotor casing, as before mentioned.

In the case of the first and third compartments of the settling tank a baffle plate is placed between the inlet of the rotor and casing and the exit to the standpipe. Each compartment is supplied with a manhole door. A screen basket is placed underneath each inlet to the tank to catch any fine zinc that may have passed through the rotor casing. A suitable gearing for rotating the machine is fixed to an extension of the shaft at the exit end of the machine, and about 1 hp is absorbed in a machine precipitating 250 tons a day.

The operation of the machine is as follows:

The solution enters the steady head, passes into the hollow shaft, and as the bore is blocked at the position corresponding to the end of the first division of the rotor, it passes out through the perforations, coming in contact with the zinc and leaving the rotor peripherically. The solution next passes into the settlement tank, and beneath the baffle plate, rising to the constant level in the standpipe to the second division. From here it again enters the perforated shaft, passing inwards through the zinc, along the shaft, and outwards through the zinc in the third section, again downwards, through the settlement tank (where the speed of the flow is greatly lessened by the size of this receptacle) beneath the baffle plate and up the standpipe, thence to the storage sumps.

By the arrangement of the settling tank it will be seen that there is but small chance of slimes being carried over to the other division. The rotor revolves from one to one and a half times per minute, and this is fast enough to allow of a slight motion of the zinc in their sections, which is as much as is desired.

All gold slime loosened from the zinc passes to the tank beneath; this can be removed at any time without stopping the machine, by closing the valve connecting the rotor casing and the settlement tank, and allowing the solution to overflow the division plate, forming the first and second compartments. The contents can then be pumped into a filter press, the solution from this being returned to any rotor desired. By means of the manhole before mentioned the inside of the tank can be washed out, this closed and valve slightly opened until settling tank is full of solution, then the valve opened full.

With reference to zinc consumption, it may be stated that the only zinc taken to acid was that which passed through the rotor in the form of shorts during its operation.

The following is a summary of the results obtained over a period of from November 4, 1908, to May 26, 1909.

Runs were made with strong, weak and slime solutions, respectively, the results obtained being as follows:

	Tons of solution per cubic foot of zinc per 24 hours	Value of solution entering, dwts.	Value of solution leaving, dwts.	Percentage of extraction Per cent.
Strong	1.01	2.221	0.053	97.6
Weak	1.84	0.383	0.029	92.3
Slimes	1.53	0.460	0.031	93.2

The above figures represent the mean of assay results over the individual runs.

At the clean-up the solution is shut off, the belt on step cone shifted to faster speed and rotor run on this for a few minutes, then stopped. (We might here mention that the sections on our experimental machine were fixtures, also there was no settlement tank below.) The sections on the top side were opened up, the zinc taken out and rinsed, though it was found that there was but a small quantity of loose slimes entangled. The zinc was returned and the section filled up with zinc from the second division. We found that finely cut filiform zinc broke up into shorts, when using strong solution, so that coarsely cut zinc would be preferable.

When coarse zinc or clippings are used, the adhering gold may be removed in an acid bath, as it was found in the case of clippings that 94 per cent of the gold was removed in a 5 per cent acid bath in 15 minutes, any deteriorating effect on the clippings being negligible. After the acid bath the zinc is thoroughly washed in clean water, the sections opened and examined, and fresh zinc added where necessary; it is found that the zinc in this form can be used in the rotor for a long time with a minimum consumption of both zinc and acid. To remove the gold from the zinc the sections are placed in a drum, which is revolved in the acid bath. We experimented for three weeks in our rotor with clippings and found the precipitation as good as under the conditions of the same space packed with filiform zinc (finely cut), the weight of clippings being 11 lb. to 1 lb. of shavings.

Our experimental machine was somewhat crude, and devoid of perhaps the greatest mechanical essential to its success, i. e., the settling tanks, the solution passing directly from one division to another without separation of precipitated slimes. The advantages of the rotor may be summed up as follows: (1) Ready access by authorized persons to the gold slimes, without stoppage of precipitation, enabling a daily clean-up to be made if required. (2) With clippings and coarsely cut filiform zinc, absence of breaking down and readiness of removal of adhering gold in an acid bath without consumption of all the zinc, with a consequent saving of zinc and acid. (3) Clean-up quick and cleanly with a consequent advantage of a minimum of loss. (4) Shortness of time rotor is out of action during dressing. (5) No fouling of zinc. (6) While in operation no danger of theft of gold slimes, as all valves would be locked.

In the discussion which followed the reading of the paper, the chairman, Dr. James Moir, remarked that on theoretical grounds, any rotary process will expose a larger surface of zinc, but, of course, it remains to be seen whether any particular device is successful commercially.

Mr. A. F. Crosse thought that there was "a great deal in this paper." The authors claim several advantages for their method, but they have left out one most important advantage, namely, the mechanical driving off of the hydrogen bubbles from the zinc; this removal of hydrogen helps precipitation.

Mr. E. T. Rand, one of the authors of the paper, confirmed that the bubbles of hydrogen on the surface of the solution are very evident indeed. There is a very violent action going on continually.

The Chemical Industries of America.*

By Prof. Charles E. Munroe.

The topic which you have done me the honor to invite me to address you upon appears on first consideration quite specific, but investigation shows that this is not quite the case. Thus we find the popular idea of a chemical industry to be one producing acids, alkalies, salts, explosives, fertilizers, dyestuffs and extracts, pigments, distillation products and elementary substances like bromine, phosphorus, sodium and others, and the officials of the United States Census Bureau in 1880 in fixing a classification, styled in the various censuses "Chemical Production" or "Chemicals and Allied Products," adopted this popular view.

In discussing this, I have said,* "A reason for the variation in the industries included at the different censuses is found in the very general and indefinite title used, for in the strictest technical sense every material thing is a chemical, and accordingly every industry in which the materials used undergo a chemical change in the process of manufacture, as in the smelting of iron from its ores or the production of leather from a hide, may be considered as a chemical industry. It is evident that if this view of the significance of the title were taken "Chemicals and Allied Products" would properly cover every manufacture except those like furniture making, machine construction, or textiles, in which the material remains unchanged in composition during the manufacture, but is turned, or cast, or woven into other shapes. The popular idea of the term limits its application, but admits as chemical industries the manufacture of gunpowder, fertilizers, and similar mixtures, whose ingredients undergo no chemical change during the process of compounding the mixtures. It thus became necessary to decide arbitrarily upon the industries to be included. Those so included at the census of 1905 may be divided into the following classes: Sulphuric, nitric, mixed and other acids; sodas; potashes; alums; coal-tar products; cyanides; wood distillation; fertilizers; bleaching materials; chemicals produced by the aid of electricity; dyestuffs; tanning materials; paints and varnishes; explosives; plastics; essential oils; compressed and liquefied gases; fine chemicals; general chemicals."

These were consequently divided into 19 different classes which were given separate treatment. The combined statistics for these classes for the censuses of 1900 and 1905 are set forth in the following table, the statistics of these two censuses only being compared because they alone dealt with the same materials.

TABLE I—CHEMICALS AND ALLIED PRODUCTS OF UNITED STATES 1900 AND 1905

	Establishments, Number	Wage Earners, Number	Total Wages	Materials Used, Cost	Products, Value
1905	1,786	59,198	$29,515,863	$176,400,680	$282,169,216
1900	1,691	46,700	21,783,335	124,018,044	202,506,076
Increase	95	12,498	7,732,528	52,382,636	79,663,140
Per cent. of increase	5.6	26.8	35.5	42.2	39.3

From Table I it is observed that there was an increase in every item enumerated, but that not only was the actual increase in the number of establishments less than that of any other item, as was to be expected, but that the percentage increase was less. This indicates that the growth of these industries was rather by increased production of existing establishments than by the creation of new ones. In fact, in a more detailed analysis it was found that in some industries the number of establishments had actually decreased, though each of the other items, as enumerated in Table I, showed an increase.

The greater percentage increase in wages over that of the percentage increase in wage earners shows that the lot of the latter was improved and possibly indicates that a better class of labor was employed, and, since the percentage increase in the number of salaried officials for these establishments was 29.6, while the percentage increase in salaries was but 32.4, it is obvious that the wage earners fared, on the whole, better than the salaried officials.

A wholesome feature to be observed is that while the increase in the number of men employed was 12,104, the increase in the number of women employed was but 413, while there was a decrease of over 10 per cent in the number of children employed. I speak of this condition as a wholesome one, because, outside of the clerical and perhaps analytical work, the duties to be performed in these establishments is essentially man's work.

*Address delivered, by invitation, on Dec. 9, 1909 at the annual meeting of the American Institute of Chemical Engineers in Philadelphia.

* Bull. 92—Census of 1905, page 9, by Charles E. Munroe.

The greater percentage increase in the cost of materials used as compared with the percentage increase in the value of the products shows the growing necessity of intelligent and careful management and skillful workmanship to prevent waste and to increase yields. This is emphasized by examination of the additional item of miscellaneous expenses, which, while less in the total than any of the values given in Table I, showed an increase of 77.2 per cent.

As indicated, the census classification of "Chemicals and Allied Products," which gave the data just discussed, is a purely empirical one, and it deals with but a very few of the true chemical manufactures of the United States. It is not possible to derive from the returns, of the various industries as taken, the data for an exact scientific classification, such as has been referred to above. Yet, in order to arrive at a better conception of the application of chemistry in manufacturing industries and its magnitude, we may follow such a scheme of classification as that employed in many chemical technologies, though here again we meet with the difficulties common to classification and we are compelled to include in our data some of the products of purely physical processes, either because these processes are operated collaterally with, or are related to, the predominating chemical processes, or else because the products are closely associated with the chemical products.

TABLE III—INCREASES AND PERCENTAGES OF INCREASES FOR CHEMICAL INDUSTRIES

	1900 TO 1905		1890 TO 1900		1880 TO 1890	
	Increase	Per Cent.	Increase	Per Cent.	Increase	Per Cent.
Establishments, number	3,013	5.6	13,116	32.4	5,587	16.0
Wage earners, average number	164,548	17.4	266,043	39.3	186,347	38.0
Wages	$137,231,195	31.3	$132,519,784	43.3	$129,656,552	73.6
Materials used, cost	718,498,053	32.4	967,923,182	77.7	322,665,809	34.9
Products, value	1,087,848,896	30.0	1,476,150,961	68.6	795,987,221	58.6

In assembling this data it should be said that in order to compare the data of the different epochs one must first eliminate from the data of 1900 the returns for neighboring industries, for the census of 1905 was a factory census which considered only the results of manufacture as carried out in factories, and not solely for consumption at the point where manufactured, as is generally the case with neighborhood industries. The results of this treatment are set forth in Table II.

TABLE II—CHEMICAL INDUSTRIES OF THE UNITED STATES 1880 TO 1905

	1905	1900	1890	1880
Establishments, number	56,580	53,567	40,451	34,864
Wage earners, avge. number	1,107,714	943,166	677,123	490,776
Wages, total	$575,635,257	$438,404,062	$305,884,278	$176,227,726
Materials used, cost	2,933,660,817	2,215,162,767	1,247,239,582	924,573,773
Products, value	4,716,490,371	3,628,641,475	2,152,490,514	1,357,503,293

Table II, imperfect though it be, both in the industries it includes and those it omits, gives a better conception of the actual magnitude of the industries in which chemical transformations play a part, and which are, therefore, really chemical industries, than Table I does and in so doing it shows the value of the products for 1905 alone to be nearly seventeen-fold greater than is set forth in Table I.

The increase is easily accounted for by noting that items, such as soap, with a product valued at over $68,000,000; glass over $79,000,000; illuminating gas over $125,000,000; dairy products over $168,000,000; refined petroleum over $175,000,000; paper and wood pulp over $188,000,000; bread and other bakery products over $269,000,000; sugar and molasses over $277,000,000; vinous, malt and distilled liquors over $340,000,000; smelting and refining of copper, lead and zinc over $461,000,000; iron and steel over $905,000,000, and many other items have been added to those embraced in Table I.

The simple enumeration of these items indicates how incomplete the statistics usually presented as those of the chemical industries are and how insufficient the popular conception of the chemical industries is. Yet even the data of Table II does not present the case in full, since all agricultural products, amounting in value in 1900 to $4,717,069,973, are really the results of chemical processes and are, therefore, the products of chemical industries, although not factory products.

As with Table I, so with Table II, the deductions are more readily drawn by observation of the increase and percentages of increase for each item at the various epochs. These have, therefore, been ascertained and are set forth in Table III.

Considering now the data of Table II, and more particularly the increases and percentages of increase set forth for each epoch in Table III, while keeping firmly in mind the fact that we are here dealing with two 10-year periods and one five-year period, it is again to be noted that both the actual and percentage increases in the number of establishments are the smallest of all the various increases set forth, and that increase for this item for the 1900-1905 period is not actually less than for 1890-1900 and 1880-1890, as should be expected, but is proportionately less, thus emphasizing what has been deduced from Table I as to the increased production of existing establishments.

Likewise the consideration of the data for this larger number of industries extending over a greater length of time shows that not only is the percentage increase in wages nearly as great at the census of 1905 as those for cost of materials and greater than the value of products, but that, while the proportionate increase in the number of wage earners for the 1900-1905 period is less than that of 1890-1900, the proportionate gain in wages is greater. In fact, all statistics point to markedly improved conditions for the wage earner in the chemical industries, and to his increased participation in the income from the enterprise. This fact is one to be reckoned on by the chemical engineer in making up his estimate for the cost of a projected enterprise, which it is proposed to install.

The statistics of Tables II and III, on the other hand, do not so markedly support the deductions drawn from Table I as to the increase in cost of materials used when compared with the increase in the value of the products in 1900-1905. However, when we consider the larger items included in these later statistics, such as iron and steel; smelting and refining of copper, lead and zinc, and others, we may each of us recall a variety of labor-saving devices which have been invented and introduced for cheapening the cost of production and handling of the raw materials of these industries, and that the inventions have increased in number and perfection with the growth in magnitude of these industries.

An increase in cost of materials is in conformity with the long-recognized natural law of supply and demand. A modification of this law through which labor may get its fair share of increase and capital may get its fair share of increase, while the actual cost may not proportionately be increased, has been brought about in recent times through the increase in the magnitude of the unit of demand, or, in other terms, the quantity handled. As stated, this has to an extent been rendered possible by the introduction of labor-saving machinery, much of which has been invented in this country.

But, in my opinion, and if I read aright the reports of foreign commentators on our chemical industries, in their opinions, the chief modification in the operation of this law has been made

in this country through the development of "team work," though the writers style it organization or systemization.

Entering on my fortieth consecutive year of college teaching I might, from what has been so persistently dinned into my ears, have been led to believe that "team work" originated in the minds of the college youths who flocked to Franklin Field or to the Harvard Stadium. Sitting on the bleachers with practical politicians and presidents, I might be led to suppose that "team work" was an invention of the professional athlete. As a fact, the idea of "team work" is a very old one and military in its essence and original application. It is embodied in our national motto. It is commemorated in the "Charge of the Light Brigade." But this older practice, while greatly promoting efficiency, demanded such unreasoning subordination that the private soldier was properly looked upon as but "food for powder," and when this system was introduced into the factory the operator became but "a cog in the machine."

The modification in this plan of "team work" which has been developed to such advantage in the industrial plants of this country has come through a recognition of the great value of individuality and the necessity for its preservation and development, and it has been demonstrated that the higher the intelligence of the individuals who merge their entities with that of their fellows in a common purpose, and the more complete their comprehension of the means used and the end sought, the more successful is the result, whether gauged by the quality, or the quantity, or the cost of the output. I am happy to say that the chemist has destroyed the older military idea, even in the army, for by his invention of high-powered smokeless powder he has compelled armies to fight in open order so that each individual must exercise his own powers in attack and defense, and be trained to take the initiative in case of necessity.

Naturally the application of labor-saving machinery and of "team work" is most readily made and yields most efficient results in the production, transportation and handling of the raw materials of our larger industries, and it is in these that we find the smaller proportionate increase in the cost of materials.

American industries, in which the chemical industries are included, have signalized themselves by the introduction of standards, by the introduction of interchangeable parts into mechanisms, by the wide application of labor-saving machinery, and by the use of "team work." Yet notwithstanding the vast resources of this country, their ease of access, and the cheapening, by methods such as described, of many of costs of production, the cost of "living," not only here, but throughout the civilized world, has steadily increased, and I attribute this largely to the work of the chemist.

At St. Louis, in 1904, I said: "Technical chemistry, then, invades the domains of economics, of politics, and of diplomacy. A striking example of its effects in economics and politics is found in the settlement of the silver question. Gold is a most widely diffused metal. It has, for instance, been shown by assayers at the United States Mint at Philadelphia that if the gold in the clay of the bricks of which the buildings of the Quaker City are built could be brought to the surface, the fronts would all be gilded. In the past our processes for the isolation of this metal have been so costly that only the richer ores would bear treatment. Large bodies of low-grade ores which have been discovered and mountains of tailings carrying values were looked upon as worthless, while enormous quantities of copper, lead, and other metals containing gold were sent into the market to be devoted to common uses, because the cost of separation was greater than the value of the separated products. Eight years ago, when the "silver question" was made the national issue, while the orators were declaiming from the stump, the chemists were quietly working at the problem in their laboratories and factories. Manhe's process for bessemerizing copper ores was combined with the electrolytic refining of the product, so that even traces of gold were economically recovered, while the cyanide processes, such as the MacArthur-Forrest, the Siemens-Halske, the Pelatan-Clerici, and others for the extraction and recovery of gold from low-grade ores and tailings, were successfully worked out and put into practical operation to such effect that by the cyanide processes alone gold to the value of $7,917,129 was recovered in the United States in 1902, which is more than was ever won throughout the whole world by all methods in any one year up to 1661, and probably up to 1701. The data for other purposes is not at hand for 1902, but the returns for 1900 show that gold to the value of $88,985,218 was recovered in the treatment of lead and copper ores in the United States, of which $56,566,971 worth was recovered in refining. It has but recently been publicly proclaimed in this city of St. Louis that the "silver question" is settled, and it is settled, but it was settled largely through the efforts of the technical chemist and metallurgist."

With the improvements in methods and diminution in cost of extraction the Pactolean stream has continued to flow in steadily increasing volume* until the flood of gold has become so great that its purchasing power has become markedly reduced, and costs, measured in terms of gold, have become markedly greater. With this condition well determined the chemist has again stepped in to increase the cost of living by requiring the application of costly methods of inspection of food, drugs, and other articles of consumption; by demanding the elimination of preservatives which permitted the abundance of the harvest being kept until time of need; or the plethora of one locality being sent to the land smitten with leanness; by insisting on the introduction of expensive sanitary arrangements. Pure-food laws are the vogue and all the other needs of man are becoming the subject of special legislation, some wise, but much otherwise. It would prove an interesting exhibit if a statistician were to assemble the actual costs in the administration and execution of these laws in this country alone during the past five years.

I speak with earnestness because I have repeatedly been a participant in these movements, and am even now engaged in an analogous humanitarian enterprise, and I know that a certain result of all such endeavors to improve the lot of man is to put the community to an increased expense.

(To be concluded.)

The Precipitating Effects of Substances Containing Various Forms of Carbon and Cellulose on Cyanide Solutions Containing Gold and Silver.**

By A. J. Clark and W. J. Sharwood.

These notes contain the results of a series of experiments and observations made by the authors at the Homestake Mine, Lead, South Dakota, together with other information on the subject, gathered from various sources.

Relative Activity of Some Precipitants.—Two sets of experiments were made on the precipitating effect of gold-bearing solutions of various precipitating substances, with the results tabulated below under Series A and Series B. In each experiment 300 c.c. of solution were taken. In Series A five grams of the precipitant were added; the mixture was stirred vigorously for a moment and then filtered, with further agitation

*The Production of Gold from 1878 to 1908 Was as Follows:

Year	World's Production		Production in United States	
	Fine Ounces	Value	Fine Ounces	Value
1878	5,761,114	$119,092,800	2,476,800	$51,200,000
1888	5,330,775	110,196,900	1,604,841	43,175,000
1898	13,877,806	286,879,700	3,118,398	64,463,000
1908	21,378,481	441,932,200	4,574,349	94,560,000

** A paper read before the Chemical, Metallurgical and Mining Society of South Africa. The complete paper, as printed in the January issue of the *Journal* of the Society, contains a list of references to existing literature.

each time the funnel was refilled with the liquid. After filtration the filtrate was passed through the filter again, and thus exposed to the sediment retained by the filter a second time.

In Series B the conditions were the same as in Series A except that a larger quantity of precipitant (which was not weighed, but was at least 20 grams) was taken, and there was only a single passage through the filter.

Series.	Precipitant.	Original assay of solution.	Assay of filtrate.	Percentage of gold precipitated.
A.	Graphite (Dixon's flake)......	\$2.63	\$2.65	0
	Bituminous coal (40 mesh)...	"	2.45	7.0
	Coke (40 mesh).............	"	2.11	19.6
	Charcoal, pine (40 mesh)....	"	1.92	27.0
	Calcium carbide..............	"	2.50	5.0
	Zinc dust	"	.02	99.3
B.	Graphite	2.73	2.73	0
	Coal	"	2.13	22.0

Repeated tests have shown similar results. Pure graphite, whatever its source, seems to be entirely without effect on the gold in cyanide solutions, and anthracite coal nearly so. The semi-bituminous or sub-bituminous coals of Western United States (practically bituminous coals, but having the high water content and brownish tinge when powdered, characteristic of lignites) have a feeble precipitating action; well-burned coke is fairly effective and charcoal much more so. Lubricants containing graphite with mineral oil, intended for use in rock drills, and the clean graphite extracted from them, are entirely without effect after several hours' contact with solution.

Either a sufficiently long contact with, or a slow percolation through a relatively large amount of bituminous coal, removed as much, in some cases, as 99 per cent of the gold in a cyanide solution, but the efficiency of the coal as a precipitant fell off with repeated use, as is the case with charcoal.

Effect of Wood Ashes Containing a Small Proportion of Charcoal on the Cyanide Extraction of Gold from Tailings Containing Pyrites.—These experiments were made in percolators upon pyritous tailings, to which various proportions of ashes were added, together with a suitable amount of lime (about 5 lb. per ton), the charges being thoroughly mixed. The cyanide solution was in actual contact with the charges four days, but the charges were drained dry once during their treatment, as well as at the conclusion.

The tailings assayed about \$1.75 in gold per ton, and upon them, under normal conditions, without the presence of wood ashes, an extraction of at least from 70 to 75 per cent would have been obtained.

The results of the experiments were as follows:

Percentage of ashes added to tailings.	Percentage of gold extracted by cyanide.
0.17	52.8
0.8	46.0
1.73	35.8
8.0	3.5

At the Homestake cyanide plants, when similar ashes or charcoal have been inadvertently introduced into the treatment vats, a very small percentage has been found to lower the gold extraction from between 70 and 75 per cent to below 60 per cent. As to the origin of these ashes, in one case it had been traced to an old stope, into which they had been dumped from the surface some years before; in another case charcoal had been produced by the charring of the timbers in a former mine fire, and had become mixed with the ore treated. Sometimes charcoal and cinders have been introduced into plants by the dumping into the mill launder of ashes from a heating stove, as a convenient means of disposal; at other times accumulations of ashes and clinker, produced by the burning of chips (collected from the mortars), had been run through the batteries.

Some years ago heavy losses were reported in the cyaniding of ore at an Australian mine, at which crushing and amalgamation were facilitated by the device of heating the ore by burning it like limestone in a furnace with alternate layers of cordwood, and quenching the heated ore with water. A similar kiln treatment has been used successfully at some small California mines, rendering refractory ore containing pyrite and tellurides more amenable, both to crushing and amalgamation in an arraster, but it seems to have proved fatal to cyaniding in the former instance, probably owing to the presence of charcoal. Park (in "The Cyanide Process," 1897, ed.), states that in New Zealand it was found advisable to hand-pick the charcoal from dried ore prior to crushing and cyaniding.

Several instances have been reported where "graphite" ore (usually slate or schist) has caused precipitation. Most likely this is due to the fact that the carbon in such carbonaceous schists is often far from being completely converted into graphite, and may exist largely in the form of hydrocarbons, in a condition similar to that of partially burned coal or wood.

Precipitating Effect of Chips, Charcoal, etc., Upon Gold- and Silver-Bearing Solutions.—Some floating rubbish, consisting of charcoal and charred pieces of wood, as well as some clean chips and twigs (which came from a settling dam and creek bed) and particles of coke (which came from the smokestacks of the locomotive and steam shovel) were skimmed from the surface of the cyanide solution in a slime agitator vat.

The solution contained approximately:

Gold, 0.023 oz. per ton (\$0.47).

Silver, 0.28 oz. per ton (\$0.14).

Potassium cyanide, 0.025 per cent.

The skimmed rubbish was rinsed twice with water, and dried at 100°C. It was then divided into two portions, one containing the charcoal and charred wood, and the other the clean chips and twigs. The two portions were then weighed, some of each being burned in clean roasting dishes in a muffle. The substances were assayed, before and after burning, with the following results:

No.	Material.	Proportion of total weight of original sample.	Ounces per ton. Gold.	Ounces per ton. Silver.	Values per ton. Gold.	Values per ton. Silver.	Total.
1.	Coke charcoal and charred wood	40%	2.25	7.50	\$45.27	\$3.75	\$49.02
2.	Ash of same....	⅛ (or 25% of total ash)..	18.00	60.00	365.40	30.00	395.40
3.	Clean chips and	total ash)...	0.96	10.8	10.48	5.40	24.88
4.	Ash of same....	¼ (or 75% of total ash)..	0.96	10.80	19.48	5.40	24.88

As neither of the two classes of material carried more than its own weight of solution, when removed from the vat, obviously a considerable precipitation had occurred in proportion to the weight of the material, the coke, charcoal, etc., precipitating the gold contents of approximately 100 times their weight of solution, and the twigs, etc., precipitating ten times their weight, the corresponding amounts for silver contents being 27 and 10, respectively.

In reply to a suggestion by Mr. Caldecott that these chips, etc., might have been partially burned or charred, it may be stated that they were to all appearance unaltered. It is possible, however, that some of them had lain in the dam or creek for months, or years, so that decay may have commenced.

Decaying Wood.—That decaying wood is an active precipitant for gold in cyanide solution was evident from a series of samples taken from a residue dam, the sand discharged into which contained appreciable amounts of solution as well as traces of dissolved gold, so that the aeration consequent on discharging no doubt resulted in the dissolution of a little more gold. While the average assay value of the sand was lower than that of the residue as discharged, the lower strata were slightly higher in gold contents, as might be expected from the leaching that had since taken place. At two points, however, a decided concentration of values was noted; one of these was found to be in the neighborhood of a pine post, and another around the decaying stump of a tree that had been killed by the residues. Mr. Caldecott's suggestion that the effect of the wood fibre itself is practically nil, and that apparent precipitation by wood is due merely to absorption of solution, is confirmed by our next series of determinations.

Absorption of Gold and Silver by Cellulose.—Several writers have published experimental results showing a large decomposition of cyanide and also a considerable precipitation of precious metals, due to contact with wood, canvas, cocoanut matting and other fabrics used as filters—all forms of cellulose. Some of the writers, working on a laboratory scale, had failed to take into account the ratio of the surface of the precipitating material they used to the volume of solution experimented upon, and did not then compare this ratio with that which would have resulted by working on a large scale. Consequently some operators have been misled with believing that discrepancies were attributable to precipitation by the wood of tanks or filter bottoms, and therefore to hope that, at some future date, the burning of the material would reimburse them for their supposed losses.

As the writers referred to differed considerably from one another, either as regards their opinions, or in experimental results, we give some of our results obtained by examination of various materials that had been exposed to gold-and-silver-bearing solutions for considerable periods.

(1) **Materials from a Sand Leaching Tank.** This was nearly 40 ft. in diameter, the bottom having an area of 1200 ft. It had been in use over a year when the first tests were made. The values given represent the contents of the entire material in the tank, through which many thousands of tons of solution had circulated, carrying up to $6 per ton in gold, and up to $2 silver.

(a) Bottom Filter Cloth of Canvas.—8-oz. duck, 1,200 sq. ft. in use for eight months. Entire cloth: gold, 5 cents, silver 2 cents.

(b) Bottom Filter of Cocoanut Matting.—1200 sq. ft. in use 12 months. Entire filter: gold, 46 cents; silver, 3 cents.

(c) Wooden Slats.—These supported the filter and were of unpainted Oregon pine, 3800 running feet with a cross-section of 2.5 x 1.5 inches, about quarter of the material being crozed out; altogether about 75 cu. ft. In use 12 months. Entire material: gold, $16.60; silver, $5.90. Wood per cu. ft. gold, 22 cents, silver 8 cents.

(d) Fine Slime.—This had accumulated under and between the filters during eight months, and consisted of fine ore, together with precipitated carbonate of lime; altogether, 200 dry pounds. Entire material: gold, 20 cents; silver, 4 cents.

In the last case, and probably in all, most, if not all of the values were contained in solution absorbed and not necessarily precipitated.

(2) **Tank Staves.**—(a) The staves of a similar large leaching tank, after use between three and four years with sand averaging $3 gold and $1 silver value per ton. They were of California redwood, originally painted inside with two coats of P. and B. paint, and outside with red oxide of iron in linseed oil. A slight coating of carbonate of lime had formed on the inside. A large sample from these staves, burned and assayed, yielded only traces of gold and silver.

(b) Similar staves from a leaching tank in use at another plant for four years contained 40 per cent moisture. The dried wood contained gold, 47 cents per ton; silver, 3 cents per ton.

(3) **Precipitating Box.**—A precipitating box of 1½-in. lumber was painted inside and out with P. and B. paint, and used three years to precipitate low-grade cyanide solution with zinc shavings, the slimes averaging about $4 to $5 per lb. Samples were taken by boring completely through the wood at various points in sides and bottom, and were burned and assayed. A little zinc slime was visible on the surface.

The average value of the material, including a trace of adhering precipitate was: Sides, 0.75 cent per sq. ft.; bottom, 2 cents per sq. ft.

(4) **Mine Timber.**—A piece of blackened but sound timber (yellow pine) which had been some time underground, and contained ferrous and ferric sulphates derived from mine water was tested. At the time of the test it contained 56 per cent of water. Kept in contact with about three times its weight of cyanide solution, which assayed $1.20 per ton gold value, no precipitation took place in 20 hours. It seems evident, therefore, that wood, when well painted with any suitable protective medium, absorbs little more than traces of precious metal from cyanide solutions of ordinary value.* As dry pine and redwood absorb about their own weight of water, one would expect such wood, if dried after a thorough soaking in solution to assay the same value per ton as the solution taken up—evaporation and precipitation excluded. Alternate soaking and drying or evaporation on the outside of unpainted wooden launders or tanks in a dry climate, might be expected to result in a distinctly higher value in the wood. Adhesion of rich telluride slime or floured amalgam may also cause an increased value.

It is difficult, however, to reconcile with one another the results obtained by the following authors, and only those of Bosqui are at all in line with our own experiments. The other writers named worked entirely on a laboratory scale.

S. H. Williams (*Eng. and Min. Jour.*, Sept. 9, 1905, p. 80, 435) found that an 8-in. wooden launder, 75 ft. long, used seven months at a cyanide plant in New Mexico, having passed 63,000 tons of solution, worth $3 per ton, contained: 2.766 oz. gold and 32.646 oz. silver in 15.5 cub. ft., or 0.18 oz. gold and 2.1 oz. silver per cub. ft., or a total value of about $4.65 per cu. ft. An apparent typographical error in the original article makes the value $60.45 per cu. ft.

A. N. Mackay (*Trans. Inst. Min. Met.*, 1905, p. 14-41; *Min. and Scient. Press*, June 17, 1905, p. 90-387) states that red pine, from a tank used 18 months, in which had been treated only 1200 tons of ore containing 20 dwt. of gold per ton, yielded 1.24 oz. gold per ton of wood.

F. L. Bosqui (*Eng. and Min. Jour.*, Feb. 26, 1898, p. 65-248) experimented with pine and redwood dressed and rough, both with intermittent exposure and drying, and with continuous immersion, for periods up to 12 months, using solution which averaged $5 gold per ton and more or less silver. The highest absorption was with rough pine, exposed altogether about 12 months, this assaying $5.18 gold and 14 cents silver per ton of wood.

On the whole, it seems probable that the precipitative effect of charcoal may be occluded gases, but definite proof is lacking. S. Brussow (*Zeit. Chem. Ind.*, Kolloide, 1909, p. 5-137; *Jour. Chem. Ind.*, Oct. 15, 1909) in a recent article, attributed the precipitation of gold from haloid salts by charcoal to absorption. This seems most unlikely, as he admits that the chlorine of gold chloride remained "almost entirely" in the solution; and we have found that charcoal, which has been in contact with solutions of either chloride or double cyanide of gold, is thoroughly impregnated with metallic gold easily distinguishable with a good lens or low power microscope.

On the Determination of the Atomic Weight of a Chemical Valence and on the Mean Chemical Energy Per Unit of the Atomic Weight.

By Dr. Gustavus Hinrichs.

The Weight of a Valence.—After reading the paper in the March issue, it will be readily understood why the ratio H to O did not come out exactly equal to 1 to 16, but gave for $O = 16$ values for H slightly in excess of unity. It is this excess that foreshadowed the separate existence of the chemically active portion of the hydrogen atom.

Supposing the slight excess to be due to the hydrogen alone

*When launders of unpainted wood are used in the Plattner chlorination process they absorb gold enough to make it worth while to burn them to recover it. The same is true of canvas used for concentration in mills where floured amalgam escapes the plates or where the tailings contain fine gold or rich tellurides. Absorption of silver similarly takes place in hyposulphite leaching. This is preventable by soaking the launders, etc., in paraffin or painting with asphaltum.

and due to the smallest weight of matter imaginable (a pantogen atom), we have found the atomic weight of pantogen (the primitive ponderable matter) equal to 1-128 of our unity, as already referred to in the preceding paper.

But this view of valence cannot be restricted to one chemical element, to hydrogen, which, on account of its small atomic weight, would reveal it first; it must be a general property for all elements. We should, therefore, have two such prominent panatoms on oxygen, three on nitrogen, four on carbon.

Calling the weight of this panatom-valence v and retaining the absolute values for the nullovalent mass of the element-atoms we shall have, for example, the entire atomic weight of silver nitrate $170 + 10\,v$.

Hence the atomic ratio of silver nitrate to silver, which for $v = O$ is $R = 1.57407$, will become $R' = R\,(1 + 0.050\,v)$.

This method of calculation is general and now will have to be applied to all cases. Let us see whether we can get a determination for the value of a valence from the existing syntheses of silver nitrate, made so carefully by Berzelius, Stas and Richards. We must, however, remember that the values of Stas are affected by systematic errors which do not show in the work of Richards, because he has used nearly the same weights of silver in all his determinations. For this reason it will be impossible to take the value calculated for v from this synthesis as entirely exact.

The analytical ratio according to the determinations of Stas is 1.57473; according to Richards 1.57479. The atomic ratio for $v = O$ is 1.57407, giving enormous excess of 66 to 72, which has remained a good deal of a puzzle for a long time. We have made various attempts to get at the real reason of this enormous excess without satisfaction beyond the point that the fact stated by Schützenberger fully accounts for the systematic error of Stas and for his two values, the one for dried, the other for fused nitrate.

The above relation gives

$$R' - R = 0.00072 = 0.050\,Rv = 0.079\,v,$$

from which we get $v = 0.009$ to nearest thousandth of a unit.

The synthesis of water by Noyes gives the same value as can easily be verified. It is true these two series of determinations belong to the best we have, but it will not do to accept them as final and *absolutely exact* in this matter, which is close to the limit of precision of analytical work.

From the investigations I have been able to complete I am sure that the value v of nine-thousandths of a unit is *a higher limit*, and that the true value is less than this amount.

It will now be necessary to apply this method to all the 300 reactions used during the past century for atomic weight determinations. For $v = O$ this work has been completed; the results have been put into five such tables as the first, published last July in this journal. The results have been discussed for two of these tables in a recent article in the *Moniteur Scientifique*, and the general results have been represented by diagram and table in connection with my Quelques Letters, page 39, just from the press.

There can remain no doubt but the absolute atomic weights are true as a first and a very close approximation. But it will now be necessary to repeat the reduction of this entire mass of data, the product of laboratory work of a hundred years, for a convenient assumed value of the weight of a valence. From the results of this work the true value of v can then be readily estimated.

This second approximation—which will probably be the final one—we have already carried out in a number of the most important determinations, using the value $v = 0.005$ as the most convenient and practical.

The following more formal statement of the present condition of this great problem may be useful:

I.—The principal part of the atom of any chemically active element is not chemically active, but nullovalent.

II.—The weight of this nullovalent part is strictly commensurable, generally to the unit, not unfrequently to the half, rarely to the quarter, and still more rarely to the eighth of a unit of our scale.

III.—The active part of the valence consists of as many panatoms prominently placed at one end of the prismatic or discoid nullovalent mass as the valence. True At. Wghts., pages 222-223.

IV.—The higher limit of the weight of the unit valence is 0.009; its true value may be 0.005 only, and will have to be determined by a second, final revision of the laboratory work done during the past century.

V.—The atoms of the argonoïds or nullovalent elements have a definite geometrical form without polar or prominent panatoms.

Energy of Chemical Reactions.—The combination of 2 gram atoms of hydrogen with 1 gram atom of oxygen sets free an energy equal to 68 kg calories, in round numbers.

The combustion of 1 gram of hydrogen thus produces 34 kg calories.

There is no other element or substance known which by combustion produces as high an amount of caloric energy.

We cease to wonder at this exceptional position of hydrogen when we consider that in a hydrogen atom the chemically active accelerative force is weighed down by the smallest inert atomic mass, namely, of one unit only.

By following this trend of examination for the most prominent oxygen and chlorine compounds, we shall find the caloric energy per unit of mass quite regularly and rapidly diminishes with the increase of the nullovalent mass, as it ought to do, if our above deduction is correct.

The following two tables show that this remarkable diminution of the chemical caloration with the increase of nullovalent matter of the atoms is indeed a fact.

TABLE I.—FOR AO.—Hinrichs' Principles Chem., 1874, p. 148.

Formula.	Caloration in Kgr. Degrees C. For Compound.	For One O.	Weight A.	Per Unit Weight of A.
H_2O	68	68	34	34.0
CO_2	96	48	6	8.0
CO	30	30	12	2.5
SO_2	71	35.5	16	2.22
P_2O_5	381	76	12.4	1.63
P_2O_3	97	32	21	1.52
As_2O_5	222	44.4	30	1.48
ZnO	85	85	65.5	1.30
FeO	69	69	56	1.23
SnO_2	138	69	59	1.17
As_2O_3	154	51	50	1.02
CuO	44	44	63.5	0.69
PbO	55	55	207	0.26
Ag_2O	12	12	216	0.06

TABLE II.—FOR ACl.—Hinrichs' Principles Chem., 1874, p. 148.

Formula.	Caloration in Kgr. Degrees C. For Compound.	For One Cl.	For Weight A.	Per Unit Weight of A.
HCl	24	24	1	24
$NaCl$	95	95	23	4.13
$KaCl$	101	101	39	2.59
$FeCl_2$	99	49.5	28	1.76
$ZnCl_2$	101	50.5	32.7	1.55
$SbCl_3$	86	29	40	1.38
$AsCl_3$	75	25	25	1.00
$CuCl_2$	59	29.5	32	0.92
$PbCl_2$	90	45	103.5	0.43
$AgCl$	35	35	108	0.32

This may be sufficient for a preliminary statement of the general mechanism of chemical activity.

ST. LOUIS, MO., March 12, 1910.

Notes on Chemistry and Metallurgy in Great Britain.

(*From Our Special Correspondent.*)

Grading of Pig Iron.

Important Proceedings.

In consequence of the resolution passed at the last autumn Congress of the International Testing Association at Copenhagen, that for the purpose of defining the quality of pig iron more accurately than was possible by the present method of grading by fracture appearance, the committee having the matter in hand should inquire in the various countries concerned as to how far specifications by analysis could be usefully substituted for grading by fracture, a meeting of representatives

of bodies interested in the iron and steel industries was held at the Iron and Steel Institute on Feb. 10 under the presidency of Mr. J. E. Stead, who represented the Iron and Steel Institute and the Cleveland Institution of Engineers.

Mr. P. Donaldson, on behalf of the Scotch Pig Iron Trade Association, wrote expressing his opinion that grading by analysis was the correct method to adopt; but, as yet, he questioned if the departure from the grading by fracture would be accepted in Great Britain.

Mr. H. Pilkington (British Foundrymen's Association) wrote pointing out the different conditions existing in England and in America, where practically all the foundry pig was made from hematite. The value of the fracture method of grading had been proved, yet it was somewhat crude when numbers alone were used for classification. An improved method was desirable, because fracture, by itself, was not a reliable index of definite properties. All the suggested chemical specifications were open to objection, and their authors did not always appreciate the commercial aspect of the situation. At present the only practicable course was to keep to grading by fracture numbers and sell on the silicon content.

Mr. J. E. Stead then rose, and after referring to the great difference between conditions of trade in England and those in America or Germany, said fracture appearance had sufficed for many years for large export sales. Grading by analysis only would considerably enhance the cost of pig iron, and it would be better that the change should be gradual, as, in fact, it was coming about now, especially in some consignments to America and Germany. British makers did not object to selling by analysis, but the cost would increase, and at present sales by analysis were not applicable to the trade generally. Another question for consideration was the storing of surplus pig, and he believed that ironmasters, warrant-holders and storekeepers would oppose the change on account of the increased expense and the inconvenience it involved. He objected to any change from the existing practice.

Mr. T. C. Hutchinson (Cleveland Ironmasters' Association) said the system of grading by fracture appearance had proved its efficiency for a period of over 60 years, and fracture appearance did to some extent indicate the analysis. In iron from Cleveland ore the phosphorus, manganese and carbon were practically uniform, and the variation in silicon and sulphur was shown by fracture sufficiently for every practical purpose. In the case of large sales of iron intended for steel making, sale by analysis was desirable and would doubtless become more customary, but for general trade purposes the existing grading met every requirement. He quite agreed with Mr. Stead's observations as to storing by analysis. Cleveland iron was bought in big lots by large firms who sold it in small quantities, and in shipping such large cargoes it would not be practicable to keep small analyzed parcels separate. He was sure that makers, merchants and buyers would all object to the proposed change; and, on behalf of the association which he represented, he had to state that its members would refuse to be bound by any resolution to grade their iron by analysis which might be passed by the meeting.

Mr. H. J. Skelton (British Iron Trade Association) believed that the agitation for the proposed change began in the United States in consequence of difficulties which arose when sandless pig was first produced there. It was well known that almost every parcel of pig made in this country was analyzed. If pig iron were to be sold by analysis a difficulty would generally arise in fixing limits of variation. He dealt largely with special pig, of which analyses were always given regardless of its destination, but the analysis was not guaranteed, in order to provide against possible rejection on account of small variations. Although analysis was becoming more customary, it was not possible for British makers to agree to invariable sale by analysis.

Mr. J. E. Stead remarked that the agitation was not coincident with the advent of sandless iron in America. Foundrymen learned the value of making their mixtures in accordance with analyses, and for that reason were now adopting the practice of buying by analysis.

Mr. W. F. Foster (Staffordshire Iron & Steel Institute) said the information as to composition to be obtained by fracture had not yet been completely worked out. The comparison of fracture with analysis would give more knowledge than a superficial observer would credit. Fracture revealed comparatively small differences in phosphorus content.

Mr. W. H. Butlin (British Iron Trade Association) stated that there was an overwhelming majority of the members of the association he represented in favor of the retention of grading by fracture. Those in favor of fracture grading represented an annual output of 1,476,000 tons and those against it only 120,000 tons. Purchase by analysis was progressing in this country. It was certainly beneficial in the case of foundry pig, and might lead to the use of cheaper iron for certain purposes, and this scientific mixing might bring about economy in manufacture.

Mr. J. E. Stead mentioned that purchasers were protected by legal decisions which established certain limits to permissible variations in analysis.

Mr. H. J. Skelton remarked that British pig iron was superior to the product of other countries. Even in Germany, with scientific control, the use of British pig iron was indispensable because the native pig did not yield the desired results.

After some discussion as to the wording of the resolution to to be put to the meeting, Mr. T. C. Hutchinson said he agreed with Mr. Foster that the extent of the information given by fracture appearance was not yet appreciated. Selection by analysis alone was impossible, and fracture appearance gave a very good indication of the composition of the iron.

Mr. G. H. Roberts (Royal Arsenal) proposed: "That the conditions governing the sale of pig iron in Great Britain make it undesirable to recommend any immediate change in the existing practice of grading, whether by fracture or by analysis."

This was seconded by Mr. W. H. Butlin, and carried unanimously.

The resolution will be communicated to the International Testing Association by Mr. G. C. Lloyd, member of the council for Great Britain.

Properties of Alloys of Copper, Aluminium and Manganese.

At the meeting of the Institution of Mechanical Engineers on Feb. 18 the discussion on the ninth report to the Alloys Research Committee (abstracted on page 154 of our March issue) was resumed by Dr. Glazebrook, who said that the results of the high-temperature tensile tests agreed closely with earlier observations and demonstrated that a considerable increase in temperature did not diminish the strength of the alloys, but had a tendency to augment it. With regard to abrasion tests three of the alloys exhibited much less loss than rail steel and tool steel. As to corrosion the degree to which some of the alloys were affected was but slight, and those alloys appeared to be really valuable.

Mr. Sherard Cowper-Coles said that electro-deposited metals might have quite as high a tensile strength as smelted and rolled metals. The study of cold electro-deposited metals and alloys would assist in clearing up several obscure points in metallurgy. Lantern projections of photomicrographs were employed to demonstrate the speaker's contentions. One showed electro-deposited copper in crystals at right angles to the cathode surface, which corresponded to the surface of the ingot mold in casting. Another was a section of a copper strip deposited in a fine V-shaped spiral cut in a mandril. If the groove were rounded instead of angular the arrangement of the crystals would be radial, and weak cleavage lines would occur. A third slide exhibited the setting of the crystals and how the deposited copper was removed in a continuous strip. The effect of particles of impurities was then shown with crystals radiating from a minute nucleus. Such structure might account for the breaking up of metals during rolling. Cast metals might

contain small particles of foreign matters which would similarly cause radial crystallization and weak cleavage lines. The effect of variation in the rate of rotation of the anode was demonstrated by the deposit of copper on a cone. The tensile strength of the copper taken from near the base of the cone was 24 tons per square inch, while the copper near the apex of the cone gave only a few tons. It was conclusively established that metals having all the various physical properties of cast, drawn or rolled metals could be produced by deposition without any heat treatment, rolling or drawing.

Mr. H. F. Donaldson doubted the utility of some of the alloys reported on because of their cost. Equally good tensile strength could be obtained with much cheaper ingredients. He would compare the alloy No. 2 of the author with one containing 36 per cent of zinc, 55 per cent of copper, 2 of iron, 4 of manganese, and 3 of aluminium, having a tensile strength of 47 tons and 30 per cent elongation, which cost but £10 per ton as against £17 per ton for the "No. 2" alloy. He questioned if manganese was the best material to add, and thought nickel might give better results. He had brought a tool made from an alloy consisting of 90 per cent of copper and 10 per cent of aluminium, hardened by hammering. It was used in a cordite factory, and retained its sharpness for fully 48 hours. The speaker produced some bronze knives, used in cordite works, which had thin blades with very sharp edges.

Mr. H. L. Heathcote said he had experimented during the last two years with light aluminium alloys, with the object of producing a non-corroding alloy for cycle rims. He found that pure aluminium corroded far less than an alloy containing 3 per cent to 4 per cent of copper when acted on by solution of sea salt and moist air at 60° C. Alloys of aluminium with 1 per cent to 5 per cent copper, of aluminium with 1 per cent to 9 per cent of iron, of aluminium and nickel, and of aluminium, copper and zinc, all corroded more than commercial aluminium. The only alloy which satisfactorily resisted corrosion was one containing 1.4 per cent of manganese, which when rolled to 15-gage flat strips had a tensile strength of 12 tons, 12 per cent to 15 per cent elongation, and 0.45 per cent to 0.55 per cent contraction. He preferred tensile strength to weighing for measuring the extent of corrosion.

Dr. Rosenhain, in the course of his reply, with reference to Mr. E. F. Law's remarks on the use of a temperature of about 1000° C. and a silicon content for alloys Nos. 10 and 11 of 0.57 per cent and 0.25 per cent, said the heating certainly affected the silicon content, which was always about 0.2 per cent or 0.3 per cent, but the temperature quoted was necessary for the addition of the manganese. He did not think anybody could much improve on his results.

The Boiling Points of Metals.

A paper by Mr. H. C. Greenwood on the "Influence of Pressure on the Boiling Points of Metal" was recently read before the Royal Society. Previously work at reduced pressures had been limited by lack of material capable of maintaining a vacuum at high temperatures, and for similar reasons nothing had been done on the effect of high positive pressures. These difficulties had been avoided by arranging the whole furnace inside an enclosure, in which the desired changes of pressure could be produced. Heating was effected electrically; the temperatures were observed optically, and the boiling point determinations were made by a visual method. Experimental pressures ranged from 100 mm of mercury to 50 atmospheres. The boiling point of bismuth under 102 mm of mercury was found to be 100° C., and under 16.5 atmospheres 2060° C. The boiling points

Market Prices in February, 1910.

Copper was in the neighborhood of £60 15 0 when the month opened, but fell away during the first week to £58; thence recovered uncertainly to £59 12 0, at about which price it has remained.

Tin, after a fall to £145 15 0 on the 4th, rose to £150 15 0 during the next 10 days, and has maintained the price of £151 up to time of writing.

English Lead has been rather depressed, falling steadily from £13 to £12 10 0, afterward recovering up to £13 10 0.

Iron.—Cleveland dropped from £2 10 10 to £2 10 0, afterward recovering to £2 11 2.

Scotch Pig down from £2 16 10 to £2 16 3, following the same movements as Cleveland, closing at £2 11 2.

Hematite dropped from £3 3 10 to £3 3 0, afterward recovering to £3 4 5.

	£	s.	d.
Aluminium, ingots, in ton lots	75	0	0
Alumina, alum, lump, loose	5	12	6
Antimony, black sulphide powder, per ton	20	0	0
Borax, best refined crystal, per ton	16	0	0
Sulphate ammonia, f.o.b. Liverpool	12	2	6
Sal-ammoniac, firsts, delivered United Kingdom	42	0	0
Copper sulphate	19	10	0
Camphor, 1-oz. tablets		1	7
Caustic soda, 48 per cent, ordinary	5	10	0
Bleaching powder, 35 per cent	4	15	0
Shellac, standard T. N., orange spot, per cwt	3	18	0
Sulphur, recovered, per ton	5	0	0
Carbolic acid, liquid, 97/99 per cent, per gallon		1	0
Hydrochloric acid, per cwt		5	0
Creosote, ordinary good liquid, per gallon			2½
Naphtha, solvent, 90 per cent at 160° C		1	3
Rubber, Para, fine, per lb		8	8
Platinum, per oz	6	0	0
Zinc, sheet (Vieille Montague)	27	10	0

London, March, 1910.

Synopsis of Metallurgical and Chemical Literature.

Smelter Fumes.

The Elimination of Smelter Fume has been a serious and important problem with Western copper and lead smelters. Permanent injunctions against their operation were obtained by the farmers of Salt Lake City, Utah, and it became necessary either to abandon the works or to evolve a scheme for the elimination of sulphuric and arsenious acids from the fume discharged into the air. How well the chemists and engineers of the United States Smelting Company have solved the problem is shown by L. A. Palmer in an article in the March, 1910, issue of *Mines and Minerals*. Not only have the courts permitted the renewed operation of the entire plant treating both copper and lead ores, but the company is recovering a valuable by-product in the arsenic which is refined and marketed. All of the fumes from blast and roasting furnaces, amounting to 350,000 cu. ft. per minute are suitably neutralized and bagged. The bagging of blast-furnace fumes, which carry the sulphur as SO_2, has long been practiced, but no attempt has hitherto been made to bag roaster fumes carrying SO_3. Pot roasters are used for sulphide ores, and reverberatory roasters for blast-furnace matte. The fume from the pot roasters is conducted through a flue to a certain point, adjacent to which is a brick furnace which is fired with slack coal over a layer of lime rock, and to which a small amount of zinc concentrates is added. The fume from this brick furnace passes into the flue mentioned and mingles with the fume from the pot roasters. The zinc oxide generated thus neutralizes the SO_3 in the roaster fume forming zinc sulphate, which is subsequently settled and bagged. The fume from the reverberatories is cooled during its progress through flues leading from the furnaces, and at a suitable point their SO_3 content is neutralized by the introduction of crushed lime into the flue. The bag house ultimately receives all fume and the gases discharged from its stacks are practically colorless and invisible. The bag house is of the usual type, and the bags are shaken by a device operated outside the building. The

dust from the roaster section is returned to the roasters, while the blast-furnace dust is sent to the arsenic plant after it has spontaneously ignited and burned to a loose sinter.

The arsenic plant consists of two Brunton arsenic furnaces and a refining furnace. Clean coke fires are the source of heat in each. The arsenic is volatilized as As_2O_3, and the lead sinters and is resmelted. The arsenic fume from the Brunton furnaces is settled in a long chamber, provided with baffle walls. It is withdrawn at intervals and sent to the refining furnace, which is of the reverberatory type. The settling chambers for this furnace are of the same type and design as for the Brunton furnaces. The product is crystalline and is ground to make a commercial product. The daily output is about two tons of refined arsenic assaying 99.87 per cent pure As_2O_3. Operators at the arsenic plant are compelled to wear a suitable change of clothing and to take a bath before going off shift.

Copper.

The Sampling of Anode Copper with particular reference to the silver content has been made the subject of an investigation at the Washoe Smelter, Anaconda, Mont., and the very interesting results are presented in the March, 1910, *Bulletin Amer. Inst. Min. Eng.* by William Wraith. A disagreement between smelter and refinery led to the investigation. The smelter method of sampling consists in "shotting" the molten stream of copper into water, by "batting" the stream at intervals with a wooden paddle. The shot is then dried, cleaned and screened through a 10-mesh screen of No. 8 wire to remove fines, the oversize being further screened through a 4-mesh screen of No. 20 wire to remove the coarse shot. The undersize of the last screen is taken as the sample. The method used at the refinery is one developed by Dr. Edward Keller, of Perth Amboy, N. J., in which every fourth anode of each lot is drilled, using a 99-hole template. The holes of the template are used in continuous order from 1 to 99, one hole to each anode, regardless of the lot being sampled. For example, if one lot required the drilling of only 90 holes, the next lot would commence with hole 91. These drillings for each lot are ground to pass a 16-mesh screen, the sample being later mixed and quartered. Finally, the quarter selected is screened through a 40-mesh screen, the oversize and undersize being weighed, and the ratio of coarse to fine being carried out in weighing up the assay-ton for analysis. Still another method investigated was the "ladle-shot" method, in which a ladleful of copper is shotted by pouring the molten stream over a wooden paddle into water. Samples taken by these various methods were carefully assayed for comparison and to determine the possibility of segregation of the silver in (1) different parts of the flowing stream, (2) the cast anodes, (3) successive portions of a ladleful, and (4) in the "skulls" formed in the ladles due to the solidifying of a shell of copper.

In the smelter shotting method it was proved that there is reasonable uniformity of the charge during the pour, and that different portions of the stream give uniform silver assays. The use of a wooden paddle or of a hot clay paddle seemed to make no difference. In the refinery drilling method it was found that six anodes selected at regular intervals during the casting of a lot, each drilled in 99 places by the template, gave almost uniform assays. Methods of comparing assays from a random anode with those of the lot from which it came were also tried and gave concordant results. A table is given showing the very fair concordance of the shotting and drilling methods when carefully carried out. The investigation of the ladle method showed it to be the least satisfactory due to the segregation of silver toward that portion of the metal solidifying last. The ladle-shot samples gave considerably higher silver results than the furnace shot samples. The "skulls" were impoverished in silver. Successive samples poured from the same ladleful showed a regular increase in silver content from first to last with the "skull" much lower in silver. Under these conditions each of the ladle samples was higher in silver than the smelter shot sample. A ladleful allowed to cool completely showed a remarkable segregation in the top of the button. The conclusions reached are that the shot sample taken from the furnace stream, and the drilling sample taken according to Dr. Keller's template, will check and give the true silver content of copper; and that the ladle-shot method gives higher results due to a segregation of silver toward the portion last solidifying.

The Behavior of Copper Slags in the Electric Furnace has been investigated by Lewis T. Wright, who presents the tabulated results in a paper published in the March, 1910, *Bulletin Amer. Inst. Min. Eng.* Ferruginous copper slags treated in the electric furnace will yield metallic iron. The author has shown that the iron recovered will contain practically all of the copper, gold and silver and more than 50 per cent of the sulphur of the original slag. The buttons are hard and clean, but not brittle. The conditions of the experiments were as follows: Slag used, 700 grams to 900 grams; strength of current 70 amp to 80 amp; time of fusing 1 hour to 1 hour and 20 minutes; weight of metallic button obtained, 153 grams to 218 grams; percentage concentration, 22 per cent to 31 per cent. The slags used carried from 0.25 per cent to 0.55 per cent Cu; 0.18 oz. to 0.33 oz. Ag per ton and from $0.15 to $0.40 Au per ton. The buttons obtained carried from 0.82 per cent to 1.62 per cent Cu; 0.48 oz. to 1.4 oz. Ag per ton; $0.40 to $1.20 Au per ton, and 88 per cent to 94 per cent Fe. The slag resulting from the fusion carried from a trace to 0.1 per cent Cu; trace of 0.025 oz. Ag per ton; trace, Au and 5 per cent to 19 per cent Fe.

Tin.

Flotation Process for the Concentration of Tin Ores.—The Elmore oil flotation process, which we described in its latest development in our Vol. 6, page 187 (May, 1908), has recently found a new application to the concentration of tin ore. This is described in the article by E. S. Elmore, of the *Mining Journal,* of Aug. 28, 1909. There is an old tin mine in Dolcoath, Cornwall, where for many years past those parts of the workings have been abandoned which contain mixtures of the ordinary tin oxide (cassiterite) with sulphides of various metals, such as copper, zinc, iron and arsenic. Such mixed ores were valueless, because if concentrated on water-dressing appliances, the sulphides, or, at any rate, a large proportion of them, were collected with the tin oxide, and the resulting product was too impure for the tin smelter. For the past two years an Elmore vacuum plant has been in operation there with complete success. The complex ore, after crushing, is treated in the vacuum machine, with the result that practically all the sulphides are removed as a concentrate which is almost free from tin, and substantially all the tin is left in the tailings from the Elmore machine, these tailings being passed on to usual water-concentrating appliances for the recovery of the tin, which is found in practice to be practically free from sulphides. Some of the Dolcoath tin ores are free from impurities except copper sulphide. From this ore the vacuum process produces a high-grade copper concentrate, in some cases as high as 19 per cent of copper, which is readily salable to the copper smelter.

Following the success at Dolcoath the process is about to be applied to two other widely separated parts of the world, viz., the Straits Settlements and South Africa. With the tin concentrates from South Africa a working trial of the Elmore process on about 35 tons of this material has recently been carried out, the results being given below.

	S %	Cu %	As %	Sn %
The impure tin concentrate treated assayed	1.69	0.26	2.91	72.38
The sulphide product assayed	20.77	2.78	33.0	3.64
The cleaned tin product assayed	0.12	0.03	0.14	74.9

The loss of tin in the sulphur product amounts to only 6 lbs. per ton of material treated, while 95 per cent of the total impurities have been removed.

Zinc.

Flotation of Zinc Ores.—Broken Hill ores have presented some of the most difficult problems in ore dressing and, as a result, a number of processes have had their origin in that district. DONALD CLARK, director of the School of Mines, N. S. W., describes in the *Eng. and Min. Jour.* for Feb. 26, 1910, a combination roasting and flotation process devised by E. J. Horwood for the treatment of some very finely divided and intermixed sulphides of iron, lead and zinc. The process depends upon the fact that when a mixture of these sulphides is roasted the iron and lead are converted into oxide and sulphate at a low temperature, from 300° C. to 400° C., while the zinc sulphide is unaltered. This partly roasted mixture is then subjected to a heated-acid oil-flotation process, whereupon the zinc sulphide floats and can be collected, while the gangue with the iron and lead will sink. With suitable mechanical equipment in the way of roasters, tanks, spitzkasten, etc., an initial product carrying 32.4 per cent Zn and 22.3 per cent Pb was made to yield a zinc concentrate carrying 50.8 per cent Zn and 6.3 per cent Pb, and a lead concentrate carrying 49 per cent Pb and 2.6 Zn.

Gold and Silver.

Cyanidation of Silver Ores.—The application of cyanidation to silver ores is most largely practiced in Mexico, where the system employed is generally well known. In striking contrast to the usual method is the treatment used at the Zambona mine in the Alamos district of Sonora. As described in the Feb. 26 issue of the *Min. and Sci. Press* by B. B. KNIFFEN, the unusual feature is in the extreme rapidity of the solution of part of the silver, and the peculiar advantage of concentrating the ore prior to cyaniding. The ore is an orthoclase felspar, brecciated and filled with calcite. The mineral is argentite, distributed throughout the gangue in all sizes down to minute particles. This mineral is easily concentrated on tables, so that 50 per cent of the silver content of the ore can be removed in this way. The tailing is then cyanided. A solution carrying 0.075 per cent free KCN is mixed with the ore in the ratio of 6:1, the pulp being treated in Dorr classifiers. The sand goes to tube mills, the discharge from which is returned to the classifiers which in turn discharge their overflow to Dorr slime thickeners. The underflow is stored for delivery to filter presses as needed. In this manner the silver is extracted from the ore by merely concentrating and grinding in solution without agitation of any kind. The silver is reduced from 16 ounces to 1.3 ounces per ton.

As illustrating the sensibility of the ore to cyanide treatment the following table is given showing the reduced silver content at various stages of the treatment:

	SILVER, OZS.
Ore after concentration	8.30
After mixing with solution	4.48
Tube mill heads	5.52
Tube mill tailing	5.28
Discharge from Dorr thickener	2.72
After standing 6 hours	2.28
After a 6-hour agitation	2.18
After a 9-hour agitation	1.96
After an 18-hour agitation	1.82

For a short time the mill was operated without concentration and by cyanidation only. It was found necessary to use a solution carrying 0.15 per cent free KCN and to supplement the other treatment by a 30-hour treatment in Pachuca tanks.

Dredging Beach Sands.—An ingenious manner of overcoming the difficulties encountered in handling Nome beach sands is described in the March issue of *Mines and Minerals.* The richest portion of the beach could not be reached in the ordinary manner, as it was under tidewater. It could not be dredged in the ordinary manner, for sand and water would fill the excavation as fast as made and thus prevent reaching bed rock. Mr. E. L. Michot conceived the idea of a barge carrying a caisson which could be lowered to bed rock and through which small areas could be worked consecutively. As carried out the construction is about as follows: The barge is 75 ft. x 32 ft. over all. Through its center, longitudinally, is a well 50 ft. x 10 ft. Along each side of the well is a track carrying a head-frame mounted on trucks. The head-frame supports the caisson, which is of sheet iron and air-tight, and measures 10 ft. long, 10 ft. wide and 7 ft. high in its working chamber. The caisson is raised and lowered over the head frame by means of a hoisting engine suitably located at one end of the barge. A centrifugal pump connected with the caisson raises the sand to the deck of the barge where it is treated in a long sluice box. Pressure is maintained in the caisson equal to the outer pressure of sand and water, so that the centrifugal pump may more efficiently clean the bed rock. Gravel worth upward from $2 per cubic yard is being worked.

Chemical Engineering.

Decomposition of Soda in Steam Boilers.—It is not generally known that the ordinary soda which remains in boiler water from the softening process is apt to dissociate in the boiler and to render the water acid, owing to the generation of free carbonic acid. Lime and soda are added to water, to precipitate carbonates of calcium and of magnesium, and, further, magnesia hydrate, and in order to secure this object, a slight excess of soda has to be used. The excess must be sufficient, and yet as small as possible. This soda accumulates to a certain extent in the boiler, even when the boiler is blown off, and it is this soda which is decomposed. A case of this nature was brought before the Mannheim Branch of the Verein Deutscher Ingenieure last November. The firm of Messrs. C. F. Böhringer & Söhne, of Waldhof, noticed that their distilled water, obtained by the condensation of boiler steam, was acid. This acidity—it was not overlooked—disappeared in the course of time, and was correctly ascribed to carbonic acid. It was at first thought that some bicarbonate had found access to the boiler, in which it would be decomposed. The softener was, therefore, overhauled. When the trouble was repeated, it was suspected that the temperature in the water softener, 80° C., might not be sufficiently high to decompose all the bicarbonate; the temperature was hence raised to 100° C., boiling point, but the carbonic acid still appeared in the boiler water. After having been informed of these observations, Dr. Grünewald ascertained that Basch had proved some time ago that boiler water contained the soda, not all as carbonate, but largely as caustic soda, and that carbonic acid was given off in the boiler. Now, the presence of carbonic acid undoubtedly favors the rusting of iron, though it is not indispensable for starting the oxidation of iron in the presence of water, and this point, while not important, deserves some attention, because caustic alkali is regarded as preventing the formation of rust. (Lond. *Engineering,* March 11.)

White Lead.—By an act of the French Parliament, which took effect July 20, 1909, the manufacture and use of white lead for either interior or exterior painting and decorating is to be prohibited after five years from the date of the act. London *Engineering,* of Jan. 14, observes that this is the result of agitation started some years ago by the French Socialists, who made the most extravagant claims regarding the ill effects of white lead on the painters, causing a high death rate from lead poisoning. The bill against the manufacture and use of white lead was introduced in the Lower Chamber and was passed. The Senate sought to amend the act by providing indemnity for the manufacturers who were thus to be deprived of their business, but the Lower Chamber would not accept the amendment. The Minister of Labor was also against the amendment, thus establishing as a principle the right of Parliament to destroy private property without compensation. The entire procedure is against industrial progress. By observing suitable precautionary measures, the manufacture and use of white lead are no more dangerous than many other industries. In fact, there is said to be more lead poisoning among employees of accumulator and storage-battery works than among

painters, but no provision is made for the protection of the health of these men. The French law has evidently been passed wholly as a measure alleged to be in the interest of labor, and without regard to industrial progress and property rights. Engineers have already begun to seek for a suitable substitute for white lead as a pigment. Some experiments already carried out indicate that nothing will take its place satisfactorily and that zinc white is not at all adapted to certain uses where lead was formerly employed.

Specific Heat and Chemical Equilibrium of Ammonia Gas.—An interesting apparatus for determining the specific heat of gases is described by Prof. WALTER NERNST in *Zeit. f. Elektrochemie*, Feb. 1. He used this for determining the specific heat of ammonia gas, which is of special interest for the calculation of the NH_3 equilibrium. For the molecular heat of ammonia he finds the following formula to hold true up to 700° C.:

$$C_p = 8.62 + 0.0020\,t + 7.2 \times 10^{-6}\,t^2$$

For the formation heat of ammonia he finds at 850° C.

$$Q = 30{,}220$$

and states that it should be correct within 1500 calories. On the basis of his new determinations he finds that the application of his new thermodynamical theorem to the ammonia equilibrium gives results better in agreement with the facts than when older and less accurate figures were used.

Gas-Washing Bottles.—A recent Faraday Society paper of Dr. N. T. M. WILSMORE (read Jan. 10) describes gas-washing bottles with a very slight resistance to the passage of a gas. Three forms are described. In one, a short side tube is joined to the inlet tube of an ordinary washing bottle and bent upward so that the gas bubbles passing through it carry some liquid with them, causing constant circulation of same. In a second and more efficient form, the gas passes through a length of 5-mm tubing, slightly inclined to the horizontal. Below this, and connected to its ends, is a bulb of liquid, so that here again the passage of gas through the tube causes a circulation of liquid. The third form described is a modification of the Richardson wash-bottle, in which the pressure is reduced by lengthening the nozzle through which the gas enters the washing bulb. (From advance sheets.)

Storage of Coal.—The results of an investigation into the deterioration of stored coal, now being carried on by the Technologic Branch of the United States Geological Survey, are given by H. C. PORTER and F. K. OVITZ in the March, 1910, *Jour. Ind. and Eng. Chem.* Coal absorbs oxygen from the air during storage without forming CO_2 and the amount of oxygen absorbed accords approximately with the deterioration in heat value. Oxidation may be largely prevented by immersion in water. Methane is evolved from freshly mined coal in quantities of importance as bearing on mine explosions, but of no importance as a loss of fuel value. Outdoor tests are being conducted to determine the extent of the loss during storage in the open as compared with immersion under water. Laboratory tests are being carried on to determine changes in the yields of gas, tar, and ammonia, through deterioration in storage.

Enameling Cast Iron for industrial uses is discussed in a general way by HAROLD HOLCROFT in the *Jour. Soc. Chem. Ind.*, for Feb. 15, 1910. The object of enameling, the testing of enameled articles, the preparation and requirements of various enamels, and the principles of their application are the heads under which the subject is presented.

Electrochemistry.

Electrode Losses in Electric Furnaces.—In an appendix to his paper on electrode losses, just published in Vol. XVI of the *Transactions* of the American Electrochemical Society, Mr. CARL HERING gives briefly the results of his tests of carbon and graphite between 100° C. (cold electrode end temperature) and 900° C. (furnace temperature). Higher furnace temperatures had not yet been used in the tests. In general, the curves have but a slight slope at the highest temperature of the test (about 900°) and all appeared to tend toward becoming nearly horizontal. Hence the error would probably not be great to use these values even for somewhat higher temperatures until the actual determinations for these temperatures have been made. This would surely be far more correct than to use the older data. Reduced to a terminal temperature of 100° C. the values for about 900° C. furnace heat are as follows in the inch units specified in Mr. Hering's article in the October issue of our last volume (Vol. VII, page 442): Graphite $r = 0.000323$; $k = 0.740$. Carbon $r = 0.00148$; $k = 0.329$. They are presumably accurate to within a few per cent, and were determined from a number of readings taken with considerable care. For graphite, the electrical resistivity falls nearly rectilinearly from about 0.000330 at 390°, hence only slightly, the curve being nearly horizontal. The thermal conductivity falls faster, also nearly rectilinearly, being about 0.861 at 390°, but it seems also to tend to approach the horizontal. For carbon the electrical resistivity falls faster, from about 0.00166 at 360°; the curve is slightly concave upward and tends to become horizontal. The thermal conductivity rises quite fast from about 0.226 at 360° and also tends rapidly to the horizontal, being concave downward. The much-discussed ratio of the heat conductivities of graphite and carbon, therefore, turns out to be only about 2 to 1 instead of 8 to 1, 10 to 1 and 18 to 1 as have been claimed by others. This, at least, is the case for 900° C. furnace heat, and applies to the mean values under operating electrode conditions, and to properly proportioned electrodes.

According to these constants for 900°, the so-called "electrode voltage," for 1°, for graphite is 0.0447 and for carbon 0.0639. This means that the minimum loss for carbon is about 50 per cent greater than for graphite, and not slightly less, as has been thought before. On the other hand, the difference in cross-sections between carbons and graphites, for the same furnace and electrode length, is less than that determined from the older approximate figures, the carbons being now only 3.21 times as large as the graphites. There is another matter of interest brought out by these tests. The mean electrical resistivity (under electrode conditions) falls more rapidly for carbon than for graphite. This means that an appreciably larger half of the heat due to electrical resistance will be generated in the colder half of the electrode, hence nearer the terminal. This heat will, therefore, have a shorter path for escape to the terminal than if the heat were generated more evenly throughout, as with graphite. In other words, a carbon electrode, it seems, would be hotter a short distance from the cold terminal than one of graphite would. This, of course, is an unfavorable feature and may account in part for the increased minimum loss for carbon. It seems to explain why the "mean" thermal conductivity turns out to be so unexpectedly high.

Quite recently two interesting papers have appeared in the *Proceedings* of the Am. Inst. Elec. Eng. of March. One is a paper by Mr. CARL HERING on "the proportioning of electrodes for furnaces" (giving the results of his tests in numerous tables and diagrams), the other is a mathematical paper by Dr. A. E. KENNELLY "on the modifications in Hering's laws of furnace electrodes introduced by including variations in electric and thermal resistivity." Both will be abstracted in our next issue.

Composition of Electro-Deposited Alloys.—A recent Faraday Society paper of S. FIELD (presented Jan. 18) discusses the conditions which determine the composition of electro-deposited alloys. Continuing the study of the quantitative composition of electro-deposited alloys, those of copper and silver have been examined. For the electrolyte, a mixture of the double cyanides was again used. Ordinarily silver is more negative than copper, but the difference in their character is such as would not seem to indicate any difficulty in depositing them simultoneusly from a cyanide solution. The composition

of the deposits was obtained by dissolving in nitric acid, and estimating the silver as chloride, except where the copper was obviously small, when that metal was determined. When a copper coulometer is in circuit the ratio (R) of the weights of alloy and copper deposited in the coulometer gives a figure from which, under ideal conditions, the composition of the alloy may be determined thus:

$$\text{Percentage of silver} = \frac{241}{R}(R - 2)$$

Experiments soon proved that simultaneous deposition only occurs within very narrow limits. Thus when the metals in the solution are in the proportion of even 1 equivalent silver to 34 equivalents of copper no deposition of copper occurs under ordinary conditions of current density, but when in the proportion of 1 equivalent silver to 100 equivalent copper, simultaneous deposition proceeds more readily. To examine the effect of such varying conditions as current density, free cyanide, and temperature, the following conditions were necessary:

1. Large volume of solution, and, therefore, little change of composition during each experiment.
2. Constant addition of silver to maintain a uniform content of that metal.
3. Solution containing not more than 0.4 grain silver per litre.

Under such conditions it was found that the percentage of the more positive copper varies as follows:

1. Percentage of copper increases with C.D.
2. Percentage of copper decreases with rise of temperature of solution.
3. Percentage of copper decreases with additions of free cyanide.

Thus the results follow the usual course as previously shown for brass, and the two metals become more widely separated in the presence of potassium cyanide. In no case were the deposits of any value physically, except where the silver very largely predominated. (From advance sheets.)

Rapid Electrodeposition of Metals.—A recent Faraday Society paper (read Jan. 10) of Dr. F. Mollwo Perkin and Mr. W. E. Hughes described a rotating cathode employed for rapid electrodeposition of metals. It consists of sheet platinum spun up so as to form a narrow thimble, the upper end being open and having a stout iridium wire fused to it. This electrode, which has an active surface of 16.3 cm, is rapidly rotated within a cylindrical platinum gauze anode. In other cases, particularly when graded potential methods are employed, a spiral anode of platinum is rotated within the gauze cylinder, which then functions as cathode. In the potential measurements a cylindrical glass funnel with a glass tube sealed in the side is employed for holding the electrode.

Dr. Henry J. S. Sand pointed out that the form of electrode ultimately found most suitable by the authors very nearly approached the one used by him, and if the investigation had been extended to this a further improvement would have been found. He considered the authors' electrodes were inferior in smallness of resistance to the electrolyte, stirring efficiency, and ease of manipulation. His electrodes, again, could be used with ordinary beakers and far less wash water was required. He had discarded the use of NH_4NO_3 solution as a connecting liquid, as on one occasion the auxiliary electrode gave completely wrong results. Dr. F. M. Perkin, in reply, said the electrodes described in the paper were simpler and less costly than Dr. Sand's. He preferred the tap-funnels to beakers, and found no difficulty in raising the temperature of the electrolyte before pouring into funnel. (From advance sheets.)

Electrochemistry of Organic Compounds.—A very useful summary of recent progress made in organic electrochemistry based on papers printed between May, 1907, to September, 1909, is given by Prof. K. Elbs in *Zeit. f. Elektrochemie*, Feb. 15. The article deals with the electrolysis of organic compounds and electrochemical reductions.

Recent Metallurgical and Chemical Patents.

Iron and Steel.

Treatment of Iron Before Tinning or Galvanizing.—Tinned plates are frequently imperfect by reason of the presence of minute uncovered areas, perforations, or so-called "pinholes," in the coating metal, such imperfections being highly detrimental by reason of the tendency of the coated metal to become corroded or pitted at these points or areas. While all surfaces of iron or steel which have been thoroughly cleaned and freed from grease or oxide are very susceptible to oxidation or corrosion, such imperfections are particularly liable to occur in plates which have been subjected to an acid pickling process, and their presence may in this case be partly or wholly attributed to the persistence in metal to be coated of acid conditions arising from the baths employed for the removal of the scale. According to a method patented by Mr. Henry Howard, of Boston, Mass., the iron or steel articles are first freed from scale by the usual methods, as by immersion for a suitable time in an acid pickling bath. The articles are then immersed, preferably after a brief washing or rinsing with water or a suitable alkaline solution, in an alkaline electrolyte, being connected therein as the cathode. As electrolytes, solutions containing a carbonate or hydroxide of an alkali are must suitable. Since the sheets under treatment are the cathodes, caustic soda is formed at them and hydrogen evolved. By this procedure the cleaned surfaces are rendered far less liable to corrosion, any residual acid conditions are quickly eliminated and the metal may immediately receive a coating of tin or zinc by immersion in the molten metal in the usual way. (949,575, Feb. 15, 1910.)

Utilizing Steel Scrap.—Steel scrap, rich in silicon, etc., is usually treated by melting it in a furnace in which its silicon or other alloy content is burned away and goes into the slag and becomes a waste product. Mr. J. P. Woods Beckman, of Parnassus, Pa., takes the scrap containing silicon or other alloy content and heats it in a closed furnace whose temperature is below the temperature required to fuse the scrap in such a manner as to prevent any substantial oxidation, bringing the scrap up to a white heat. He then adds to the scrap molten steel which has been melted in a separate furnace, and thus utilizes the excess heat of this steel to melt the scrap, which has been preheated to a point slightly below its melting point. In this manner he is able to utilize practically all of the alloy content of the scrap without loss and at a very slight additional cost. (947,031, Jan. 18, 1910.)

Electrolytic Iron.—Electrolytic iron is produced from ores by the following process of Mr. Alexander S. Ramage, of Newark, N. J. (the patent being assigned to the Electro Steel Company of Canada, at Welland, Ont.). Magnetite containing titanium is heated in a rotary cylinder in presence of water-gas with an excess of hydrogen at a temperature below the melting point of iron until the iron content is reduced to a metallic sponge. The reduction of the iron occurs at a dull red heat, whereas the titanium oxide is unaffected by this treatment. The iron powder, or sponge, containing unreduced titanium oxide, but substantially free from carbon, is discharged into air-tight vessels, where it is cooled, and is then electrolytically refined in an electrolyte containing ferrous sulphate and ammonium sulphate, together with some organic material, such as glycerin or glue. The cathodes are sheets of iron or revolving tubes. The current density is 10 amp per square foot and the temperature 140° Fahr. The cathodes are heated to expel the occluded hydrogen. The titanium oxide passes into the anode sludge in the electrolytic vats. (949,004, Feb. 15, 1910.)

Gold and Silver.

Filtering Device.—Continuous filtration of slimes is the subject of a patent granted to George Ridgway, of Kalgoorlie, Western Australia, who has perfected a mechanical appliance for the purpose mentioned. The process is continuous, but is

quite different from any of the half dozen or more continuous slime processes recently devised. The inventor retains the "basket" type of filter, and alternately lowers and raises the baskets into exhaust, washing and discharge vats in his machine. The construction will be apparent by reference to Figs. 1 and 2. The annular trough is divided into sections *A*, *D*, *E* and *F*. The first is filled with the pulp to be filtered, the second with water or wash solution, the third devoted to drying and pumping, and the fourth to the discharge of the cake. The various sections are divided by suitable partitions over which the baskets are raised and lowered in their continuous path around the entire tank. The filter frames are made of iron pipe bent into a V-shape and covered with a suitable filtering medium. All of the frames in a basket are properly connected. On each set of filters is a device for engaging a track at certain intervals around the tank, whereby they are lowered and raised at the proper time. Agitators keep the pulp in a homogeneous condition during filtration. When the machine is started all of the filters in tank *A* are in connection with the vacuum apparatus and a cake of slime is formed on the filter, while the

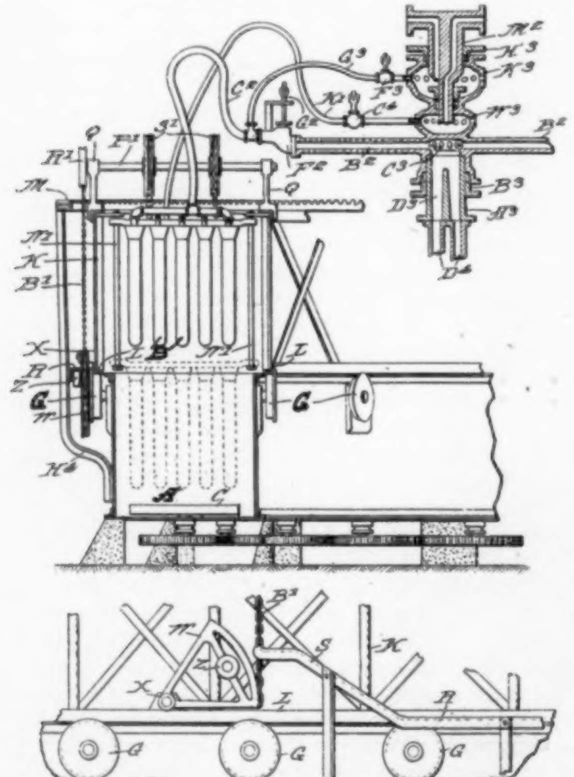


FIG. 1.—VERTICAL SECTION OF FILTER.

liquid is conveyed to a suitable chamber. As each set of filters approaches the partition between tanks *A* and *D* it is automatically raised from *A* and again automatically lowered into *D*, where the cake is washed during the progress of the filter through that tank. Arriving near the partition between *D* and *E*, the filter is again raised and kept in this position, with the vacuum still on until it arrives over tank *F*, where it is lowered and the cake discharged by compressed air admitted to the inside of the filter frame, and by a water jet directed against the outside. The filter is then ready to receive another cake on being automatically lowered into tank *A* containing the agitated pulp. (945,193, Jan. 4, 1910.)

Agitation.—The agitation of pulp or solutions in the treatment of ore by the cyanide process is effected by J. E. Rothwell and R. P. Akins, of Denver, Col., in a cylindrical tank with conical lower portion by means of pumping. The solution supplied to the pump comes from an overflow at the top of the tank and thus contains no large particles of pulp to wear the linings and working parts of the pump. The discharge from the pump enters the apex of the conical bottom, and carries with it any sands which may have settled at that point. The path of the discharge is upward through a vertical pipe placed in the center of the tank, from which it issues against a baffle or distributing plate. This causes the pulp solution to spread out evenly over the area of the tank, the heavy particles settling to the bottom and the fine slime again overflowing to the pump, to be forced upward through the

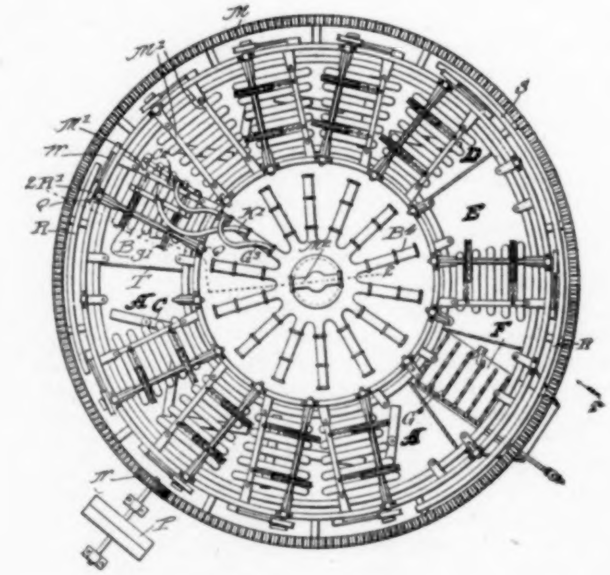


FIG. 2.—PLAN OF PLANT.

central tube, carrying the settled sand with it. A series of tanks may be used for continuous agitation and overflowing, the overflow from one tank to the next taking place through a special shape vane at the top of the tank which cuts out a uniform part of the tank content and carries it to the next tank. (951,742, March 8, 1910.)

Sand Treatment.—While the above two patents referred, one to the treatment of slimes only and the other to a mixed charge of sand and slime, a third interesting patent of a similar nature is that granted to Charles E. D. Usher, of Johannesburg, South Africa, for the treatment of sand only. Such material has hitherto usually been treated in vats by percolation, which is a slow process, and it is the design of the inventor to provide a more rapid means of treating this material. This is effected by providing in the bottom of a vat a number of radial perforated pipes connected with a central chamber. The ends of all the radial pipes are curved in the same direction with the circumference of the vat. A charge of sand having been placed in the vat, a solution of cyanide, for example, is forced in through the pipes and out of the perforations. The action of this solution is to stir the sands and to keep their surfaces bright and clean by attrition. The mass finally reaches a state of homogeneous semi-suspension. As soon as a sufficient quantity of solution is forced through the charge to collect in a layer at the top of the vat, the pump is disconnected from the sump from which the solution was being drawn, and connected with a decanter which rests in the upper surface of the liquid in the vat. The supply of solution is now continuously circulated through the mass of sand being injected through the radial pipes at the bottom and drawn off through the decanter placed in the clean layer at the top. The inlet of the decanter is usually so arranged that it draws in a quantity of air with the solution, thus providing an efficient aeration of the

mass in the vat. The process of solution and aeration is continued until the values are dissolved from the sand, whereupon the solution is drawn off and conducted to a suitable tank. The sands are then washed in the same manner as they were leached. (949,455, Feb. 15, 1910.)

Antimony.

Treating Arsenical Antimony Ores.—H. L. Herrenschmidt, of Paris, France, proposes to produce a clean antimony regulus from arsenical antimony ores by a combination wet and dry process. A preliminary roast of the coarse ore at a temperature of about 400° C. is the first step. The volatile oxides of arsenic, antimony and sulphur given off in this step are condensed for later use. The fine ores are not roasted, but are mixed with carbonate of soda and lime, with soda waste to which has been added carbonate or sulphate of soda, or with sodium sulphide. This mixture is then boiled with water under a pressure of four or five atmospheres. This operation forms antimoniates and arsenates of soda, or suphoantimoniates and sulphoarsenates of soda, or all four. The liquor containing these salts is drawn off and is now caused to react with the oxides formed in the roasting operation before mentioned. Oxides and sulphides of antimony comprise the precipitate, while the arsenic dissolves in the solution of the arsenate or sulphoarsenate of soda. The antimony oxides and sulphides are collected and reduced to a clean regulus free from arsenic. Any antimony left in the liquor containing the arsenic may be precipitated by the sulphur dioxide from the roasting process, or by any other suitable means, while the arsenic remains in the solution. The inventor describes special apparatus for carrying out the process. (948,545, Feb. 8, 1910.)

Zinc.

Smelting Zinc Ores.—The recovery of zinc from lean zinciferous material, such as zinciferous slag or lean ores, may be effected by fine pulverizing and mixing with coal dust, briquetting the mixture and then charging these briquets into a furnace with small coal or coke. Zinc is volatilized and the other materials are slagged off. The object of a process patented by Hermann Pape, of Hamburg-Billwärder, Germany, is to eliminate as far as possible the necessity for grinding the material. He has determined that the quantities of reducing material contained in the briquets and the quantity of small coal or coke fed into the furnace with the briquets is more than sufficient to effect the removal of zinc from the briquets. Consequently he has found it possible to add to the ordinary furnace charge a considerable proportion of the zinciferous material in lumps, thereby avoiding the expense of crushing and briquetting. The manner of charging the furnace is, first, small coal or coke, second briquets of zinciferous material with carbon, third lumps of the zinciferous material. (948,740, Feb. 8, 1910.)

Alloys.

Improvement in Copper Alloys.—The manner of introducing certain other constituents into brass for the purpose of increasing its tensile strength and ductility is the basis of a patent granted to S. C. Peck and W. R. Hodgkinson, of London, England. Small proportions of chromium, manganese, nickel, cobalt or zinc may improve the quality of the alloy. The preferred manner of introducing these elements is by the addition of the phosphate of the metal with a reducing agent such as carbon, to a small quantity of copper or one of its alloys. This gives a metallic solution of the phosphide of the metal to be added, and this metallic solution may then be used to alloy molten brass in the desired proportions. In the second operation some of the zinc in the brass is volatilized as zinc phosphide, leaving the brass alloyed with the metal added. An actual test was as follows: 2600 grams of brass (Cu. 70 per cent, Zn. 30 per cent) were melted in a crucible with 200 grams of a mixture of equal parts of chromium phosphate and powdered charcoal. The temperature was about 1000°C. The addition of charcoal and chromium phosphate was repeated twice at intervals of an hour. After four hours heating the cast was made and this metal containing chromium phosphide was used to improve the qualities of brass as follows: 1516 grams copper and 655 grams zinc were melted together and to the melt was added 82.5 grams of the chromium phosphide brass. The resulting metal tested 19 tons per square inch tensile strength, and showed an elongation of 72 per cent on two inches. The same brass without the chromium phosphide added showed tensile strength of 14.4 tons per square inch and elongation of 38.5 per cent on two inches. (943,159 Dec. 14, 1909.)

Paper Mill Liquor.

Regeneration of Spent Liquor of Paper Mills.—The economical treatment of the spent liquor of paper mills for the recovery of the alkali and resinous matter contained forms the basis of a process devised by Isidor Kitsee, of Philadelphia, Pa. Heretofore, it has been the custom to concentrate the liquor to a syrupy consistency, after which the resinous matter is burned or carbonized. This residue is again dissolved in water, the carbonized mass filtered out and the caustic recovered. The process not only involves the loss of the resinous matter, but is inefficient in the recovery of the alkali. To overcome the objections to this process, the inventor causes the spent liquor to be electrolysed in a diaphragm cell. The spent liquor is placed in the anode compartment of the cell, while the cathode compartment contains water to which a little sodium chloride has been added. Through the action of the current, the sodium chloride is decomposed, the chlorine going to the anode compartment, while caustic soda is formed in the cathode compartment. The presence of the chlorine in the anode compartment acidulates the solution and causes the resinous matter to separate and coagulate. The result of the operation is the concentration of the alkali in the cathode compartment and the accumulation of the resin in the anode compartment. If little resinous matter is contained in the spent liquor and the chlorine is generated too abundantly, it may be led from the closed compartment to a tank of water, thus forming a suitable bleaching agent. (942,207, Dec. 7, 1909.)

Various Metallurgical Patents.

Roasting and Sintering Ores.—Metallurgists continue to give considerable attention to the preparation of fine ores prior to charging in the blast furnace. One of the latest patents on a process of this kind has been granted to Walter G. Perkins, of London, England, and Mark L. Requa, of San Francisco, Cal. The process resembles somewhat those patented by Dwight and Young in that there is a perforated hearth on which the charge is placed, the hearth lying above funnels and a tube connected with the exhaust apparatus. There is a marked difference, however, in that the hearth is stationary instead of movable as in the other patents mentioned. The ignition of the charge is effected by a blast of gas directed onto the surface of the charge under a hood. The hood is movable and as soon as ignition has commenced at any one point of the hearth, the hood is moved to another area. The exhaust continues until the entire charge is sintered. The hearth is hinged along one of its sides and in order to discharge the sintered mass the hearth is moved to an inverted position on its hinge and the entire sinter falls on to a perforated or slotted grating, through which the fine material falls, while the large lumps are discharged at a point convenient for smelting. (951,199, March 8, 1910.)

Still another sintering device is the subject of patent granted to George G. Vivian, of Tintic, Utah. This furnace is of the reverberatory type, and is operated by hand. Ore is fed in hoppers placed along one of the long sides of the furnace, the hoppers being water-jacketed. The furnace operator rabbles the mass over the hearth of the furnace and as soon as it becomes sintered withdraws it onto the cooling floor. To control the operation of the furnace means are provided for admitting cold air above the charge. (950,798, March 1, 1910.)

Joseph Weatherby, of New Cumberland, Pa., has been granted a patent for agglomerating fine iron ores. In a rotary kiln the fine material is not heated to the point of agglomeration until it reaches a point near the discharge end, where coke or charcoal is introduced and mixed with the ore. As the mass agglomerates at this point the carbon particles are consumed, leaving the ore in a porous condition suitable for smelting. The refuse coke dust discarded at the blast furnace has been successfully used. (949,387, Feb. 15, 1910.)

In order to overcome the difficulties arising from the formation of annular rings in kilns. August Bräutigam has made use of a blast of air directed at one point of the ring until it disintegrates. The operation may be performed while the furnace is either stopped or in slow motion, the effect being to so chill the ring at a certain point that it will crack, due to contraction. When the furnace is again placed in operation the balance of the ring falls off and mingles with the ore. (13,062, Dec. 28, 1909.)

An improvement in roasting furnaces of the superposed hearth type has been made by Utley Wedge, of Ardmore, Pa. The improvement relates to the construction of the furnace whereby the furnace arches and their superposed hearths are supported on an outer structure, so that the enclosing wall of the furnace is relieved of weight and strain. Economical construction and greater facility in making repairs constitute the main features of the improvement. (946,178, Jan. 11, 1910.)

Cooling Roasted Ore.—The economical cooling of roasted ore is of importance as an intermediate step in some metallurgical operations. Frank D. Baker, of Denver, Colo., accomplishes this in a rotary cooler with cone-shaped ends, revolving in a vat of water and having a spray of water directed along its top. The buoyancy of the water is of assistance in permitting the use of a longer cylinder than might otherwise be practicable on account of the necessity of bearings between the extremities of the cylinder. The cooler is rotated by any suitable power connection. At its discharge end it is equipped with internal spirally arranged blades which advance the ore to the opening. (943,294, Dec. 14, 1909.)

Electrostatic Ore Separation.—A patent has been granted to Frederick G. Cottrell, of Berkeley, Cal., on improvements in effecting interchange of electric charges between solid conductors and gases. One of the interesting applications of the principle involved is the electrostatic separation of ore. A metallic revolving roller, connected to earth, receives a steady supply of finely divided ore from a suitable hopper. In front of the roller, parallel with its axis, and slightly above its center, is a pubescent electrode in the form of a piece of cotton-covered magnet wire. This takes the place of the metallic discharge points usually used in machines of this type, and is the main feature of the invention. The inventor claims that all the advantages claimed for metallic points are obtained in higher degree by the use of fine filaments or hairs of a textile substance, even though it may not ordinarily be considered a good conductor. For example, such materials as asbestos, cotton, wool and silk are used. Suitable receptacles are provided beneath the roller to catch the conductive and nonconductive particles. (945,917, Jan. 11, 1910.)

Various Electrochemical Patents.

Copper Plating.—Dr. E. F. Kern patents a new electrolyte for copper plating. It is a solution of copper fluosilicate and ammonium fluosilicate (or, in some cases, aluminium fluosilicate) in water, and a further improvement may be obtained by the additional use of ammonium fluoride with an alkaline tartrate. For plating iron, steel, or zinc with copper, the bath preferably consists of 100 parts water, 12 copper fluosilicate, 8 ammonium fluosilicate, 6 ammonium tartrate, and 5 or more parts of ammonium fluoride. The bath is maintained neutral or slightly alkaline by means of ammonia. For coating brass, copper "or certain other metals," the bath preferably consists of 100 parts of water, 12 copper fluosilicate, 8 ammonium fluosilicate, 8 ammonium fluosilicate, 0.06 gelatine or tannin, and 5 or more parts of ammonium fluoride. In this case the bath is acidified by free fluosilicate acid or is maintained neutral by employing aluminium fluosilicate instead of ammonium fluosilicate. When the bath is used in acid condition, it is advisable to add gelatine or tannin to the bath in the proportion of one part of solid gelatin to one part of the concentrated extract of tannin to 2000 parts of the bath. A copper anode is employed. (946,903, Jan. 18, 1910.)

Nitric Acid from Air.—Mr. Francis I. DuPont, of Wilmington, Del., who has paid considerable attention to the production of nitric acid by electric discharges through air, has been granted another patent for a furnace for this purpose. It is shown in Fig. 3. The air is passed through a silica tube *a* within which are the electrodes *b*, between which the arc *k'* is formed. The silica tube is surrounded by the glass tube *h* through which a cooling liquid is passed from *j* to *k*. The field magnets or rings *l* are energized by a polyphase current, thus producing a rotary magnetic field which causes the arc to

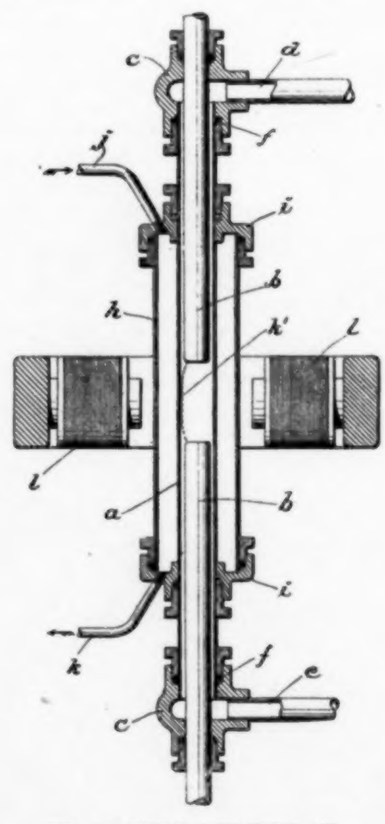


FIG. 3.—NITRIC ACID FROM AIR.

rotate around the inner surface of the silica tube. Air is forced through the passage *e* into the zone between the electrodes; it is heated by the rotary arc (so as to form nitrogen oxide), but as soon as the rotating arc passes from any portion of the air, this air is immediately subjected to the cooling action of the walls and its temperature is so rapidly reduced as to prevent the formed nitrogen oxide from being again largely decomposed. (950,703, March 1, 1910.)

Ozone.—Mr. Robert W. Rice, of Cleveland, Ohio, patents an ozonizer in which glass plates serve as dielectrics, being placed between aluminium plates. These are punched so as to provide a series of discharge points. A transformer is provided in the lower part of the apparatus. (930,347, Feb. 22.)

A large number of electrochemical patents had to be reserved on account of lack of space for our next issue, in which all electrochemical patents will be brought up to date. Several abstracts of patents of an electrochemical nature will be found above among the patents on Iron and Steel and Copper.

Smelter Fumes and Damage Suits.

By R. G. Burton and Taft Reed.

A most interesting conflict of interest between the agricultural and lumbering industries on the one hand and the metallurgical and chemical industries on the other is now being brought into more and more prominence. Ever since sulphuret ores have been smelted there have been complaints from the surrounding agriculturists, and the early law cases of England are replete with decisions on the respective rights of the parties. In the majority of cases the issue turned upon the strict right of the agriculturists and the preservation of their property against even a technical invasion by the gases and smoke from the smelters. The same conditions have prevailed for many years in Germany, and now in America the question is becoming one of greater importance than ever before. The clash has become almost a battle for very existence.

The increase of population has greatly increased the value of foodstuffs so that the agriculturist has the better right—where actually injured—to bitterly complain; where the forests a few years ago were regarded as practically worthless, having in same cases really nominal values, they have now suddenly become enormously valuable on account of their fast disappearance and a real injury to them represents a real loss of value. On the other hand, the great increase in population has given a great impetus to all metallurgical and chemical developments, with the result that any interference with these industries must inevitably mean not only serious loss to the operator, but to the public as well. Civilization demands electricity, electricity demands copper, as expanding industry demands steel, which in turn requires coke, and as the copper furnace or coke oven is interfered with in its operation, from whatever cause, so civilization must be inconvenienced and must in the end sustain a loss. What is true of the loss or injury occasioned in the manufacture of copper or coke, is, of course, true of all those commodities which in their manufacture cause to be thrown off gases deleterious to vegetation, so that on the side of copper and coke are arrayed zinc, lead, wood-pulp, commercial fertilizer and a dozen others.

"But," says the farmer or lumberman, "I am at least entitled to be paid a fair price for my timber damaged or my crops destroyed." True, but the question will arise, "Where is the dividing line. What has been killed or injured by the gas or fumes and what by the weather or other natural causes?"

It is just at this point that the real trouble begins. It is no longer a fight between agriculture on the one side and industry on the other. The matter has narrowed down to one of lawyers and courts, and most important of all, to the question of evidence. The plaintiff may be honest, his crop or his woodlands may have been injured, but in practically every case, honest though he be, his injury, to his mind, has been done solely by his neighbor who mines and smelts and cares nothing for farms, natural causes of death are lost sight of, prospective crops would have been enormous, the stand of timber and its value are prodigous and the damage to it is most pitiful to see. And those orchards! They were not infested with scale and blight and diseases innumerable and they received the best of care and attention and were of the hardiest and most valuable varieties.

So long as the crops, the orchards and the timber were of little value, the evidence required usually went only to the point of showing the fact of death and the fact of the proximity of a smelter. But now that the values of crops and particularly of timberlands have increased and will increase so enormously, the question of cause of injury will become more and more vital. What was once in a haphazard way almost conceded is now coming to be analyzed, and the true conditions so long really incomprehensible to the courts, and to the defendants as well as to the plaintiffs, are coming to be understood. Scientifically trained men have been investigating the conditions and have studied those natural causes either wholly responsible or acting as contributing factors in the damage complained of and the following surprising condition has been found: That in almost every case insects, fungi, and worst of all, fire and dessication, have been working a great part of the injury for which the smelters have been blamed and for which they have had to pay handsomely.

Damage to the forest by insects is caused either by those which kill the tree outright, or by those which weaken the tree and reduce its commercial value. Millions of feet of timber are killed each year by bark-beetles of the genus *Dendroctonus*, which attack conifers, in certain parts of the country destroying whole forests. To another beetle, *Agrilus bilineatus*, is attributed the death of most of the mature chestnut trees in the United States. One of the Scolytids, *Scolytus quadrispinosus*, has caused most of the death of hickory in the past few years in the southern Appalachians. These are only a few prominent examples of insects causing serious damage to the forest trees and could be greatly multiplied.

The ravages of fungi are seen everywhere and in all parts of the country. A striking example is the "white pine blight" which causes a discoloration of the leaves exactly similar to that caused by smelter fumes and like them causes the death of the tree. Another fungus is *Diaporthe parasitica*, which is now killing off the chestnut in the vicinity of New York City.

Worst of all, however, is the damage, direct or indirect, done by the forest fires which are more or less prevalent everywhere. In the Appalachian system, for instance, the soil is gradually but surely reaching a condition of barrenness due to the constant firing at the wrong time of year by the farmers under the mistaken belief that the value of the land for grazing will be enhanced. The common idea that fires must be severe in order to do serious damage is erroneous. A light ground fire running over the ground year after year dessicates the soil by destroying the ground litter and humus, paves the way for the inroads of insects and fungi and for the beginning of erosion; in short, disturbs the normal balance of things in the forest to such an extent that the trees are killed just as surely as though girdled by severe fires.

In view of the foregoing facts, it will be readily seen that the best and only defense for the smelting company to adopt is based on the collection of evidence in the field, section by section and township by township, which will show the relative damage done by smoke, by fire, insects, fungi and other causes. The criteria of smoke damage in such a field examination are at once simple and complex. The different causes of death, including smoke, and how each acts, may be perfectly understood, but it is almost always the case in the forest that death is due to no one cause, but to a combination of several causes. Thus, fire may scar a tree and afford entrance to insects or fungi, which in turn so weaken the tree that it falls a victim to smelter fumes, which it would otherwise have resisted.

Over large areas perhaps no one cause can be fixed upon as acting alone, and this fact would at first seem to negative a defense along these lines. It will be plain upon brief consideration, however, that it is only necessary to show that there are other causes than smoke playing a large part and the burden of proof immediately falls upon the prosecution to show how much of the damage has actually been done by the smoke, and unless he can accomplish this, his case at once falls to pieces. The judge is justified in instructing the jury, as has been done in recent cases, that unless they can settle upon the actual amount of damage by smoke, beyond all reasonable doubt in their own minds as to the accuracy of the figures that they thus fix upon, that they shall bring in a verdict of nominal damages only. This method of procedure denies to no one his opportunity for recovery by law for any damage traceable to the influence of smelter fumes. But it forces the plaintiff to substitute facts for theories and a detailed examination of the conditions for exaggerated ideas of his injury. Not even the defendants themselves have usually any idea of how small a part of the injury they are perhaps responsible.

To sum up, the financial importance to the smelting company of collecting evidence in the field of every cause other than smoke, which has killed or damaged the forest, cannot be overestimated. What special form these other causes of death will take varies greatly with the locality and can only be determined by a field examination of the particular region in question.

Automatic Gas Calorimeter.

The automatic gas calorimeter, which is built by the Sargent Steam Meter Company, of Chicago, has recently been improved in various details. A description of the improved instrument should, therefore, be of interest.

Fig. 1 shows the complete calorimeter. It consists of a wet test meter in which the gas consumed is accurately measured.

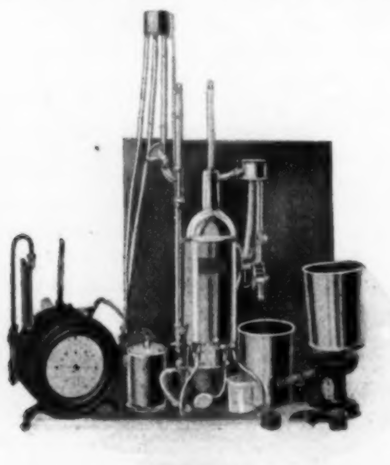


FIG. 1.—COMPLETE CALORIMETER.

From this meter it flows to a governor which maintains a uniform pressure of the gas at the burner. In the calorimeter proper the accurately measured gas is burned and its calorific value is manifested in the rise of temperature of measured quantities of water flowing through. From the calorimeter the heated water for each unit of gas burned is automatically discharged into one of the pails in which it is weighed on the decimal scales. The pounds of water, times its rise in temperature in degrees Fahrenheit, times the quantity of gas in cubic feet consumed gives the b.t.u. direct.

Meter.—Fig. 2 is a sectional elevation of the meter. The rotor is accurately balanced, and is mounted on a heavy shaft to which is attached the integrating train. The meter rests on three legs, each equipped with a leveling screw. A circular sensitive level permits of accurate adjustment. The water level is indicated in the glass gage by a pointer set in the laboratory of the makers, when the meter is calibrated, and when it is operated under similar conditions it will give absolutely correct results. A thermometer indicates the temperature of the gas metered and a manometer its pressure, both of which are necessary in reducing metered to standard gas.

One revolution of the needle equals one-tenth of a cubic foot and as the dial, made of white porcelain, is divided into 100 parts, the meter has a range before repeating from one-thousandth of a cubic foot to 100 cu. ft. A filling funnel and drain facilitate its manipulation. When the meter is used with the calorimeter, the electrical attachment closes a circuit for every tenth of a cubic foot measured, which through the dumping bucket automatically segregates the water whose temperature is raised by the unit of gas burned.

Pressure Governor.—In order to maintain a non-pulsating flame at the burner, a pressure governor is required between meter and calorimeter. The governor shown in Fig. 1 is of the inverted bell displacement type and can be adapted for any gas by the adjustable weights.

Calorimeter.—In the calorimeter every heat unit given out by the combustion is manifested in the rise of temperature of the water flowing through while a unit of gas is burned. It is mounted on three wide spreading legs, insuring stability, each of which is provided with a leveling screw so that it can be operated on a irregular surface.

Fig. 3 is a section of the instrument in which the inlet water, having a constant head at the wier *A*, the temperature of which is taken at *B*, passes down the tube *C*, and enters the calorimeter at *D*. Here the water is spread around the bottom of the instrument by the baffle plates *E* and *F*, and then flows upward around the tubes *G*, through which the products of combustion pass. The partially heated water on leaving the tubes spreads out over the dome sheet *H*, where it is heated by the hottest gases and then passes to the wier *K*; through the baffle plate *I* and around the thermometer *J*, where the outlet temperature is taken. From this wier *K* the water is discharged into the automatic tipping bucket, which delivers the heated water alternately to the copper pails.

The combustion of gas takes place in the central flue at *L*, the products of combustion passing upward to the dome sheet and then down through the flues in a contrary direction to that taken by the water. The gases are discharged at *M*, where the temperature is maintained the same as that of the surrounding air by the damper *N* and the quantity of water flowing through.

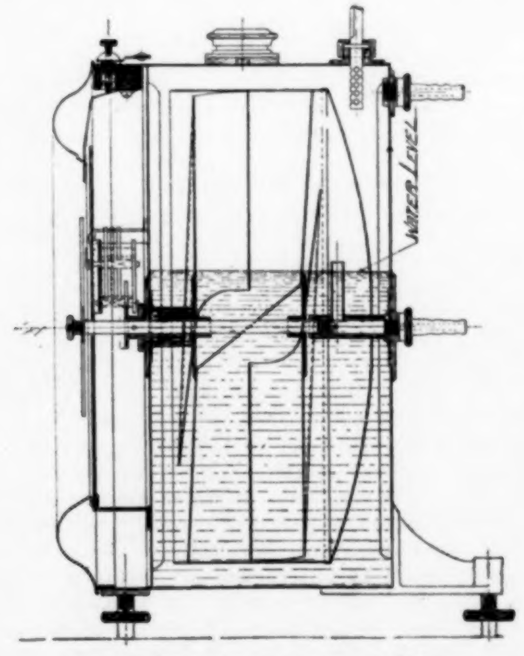


FIG. 2.—SECTIONAL ELEVATION OF METER.

Accessories.—The special Bunsen burner, adjustable for any gas, extends well up into the internal flue and the closed base prevents downward radiation. By means of a fixed mirror the operator can always see the color of the flame through the air admission opening. Two dry cells furnish the electric current for operating the releasing magnet and the weight of the water in the bucket tips it. The scales have a capacity of 10 lb., are graduated to a hundredth of a pound and when balanced with the empty pails indicate the net weight of water, whose temperature has been raised by the combustion of a 1/10 cu. ft. of gas.

With this calorimeter determinations may be made for every 1/10 cu. ft. burned, covering an interval of time from one to three minutes, and for an unlimited duration. With such a log, continuous curves of a calorific value of the gas may be plotted and an absolute record of the operation of the gas-generating apparatus may be obtained and preserved.

When extreme accuracy is required in reducing metered to standard gas, a special draft gage is used to get the pressure of the gas at the meter. It is used in connection with producers, furnaces, and ventilating apparatus.

The foreign matter in gas is determined mechanically when it is tested for its calorific value or by a separate operation.

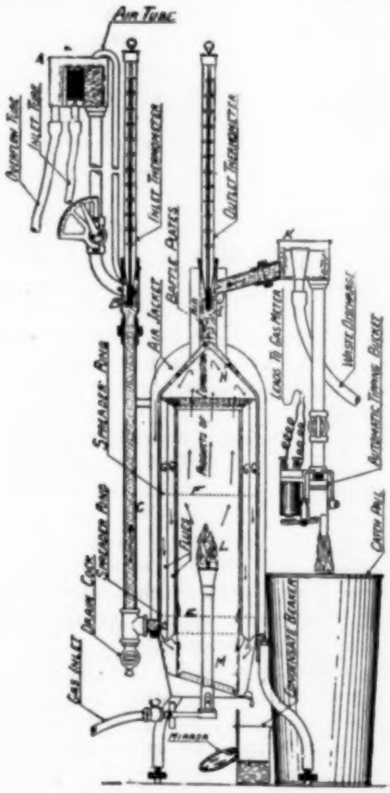


FIG. 3.—SECTION OF CALORIMETER.

In either case the unit of gas analyzed is determined by the meter. The tar in producer gas, the dust in blast furnace gas, the moisture in any gas or air, and the dust in the atmosphere is determined by special filtering apparatus, built by the Sargent Steam Meter Company.

Centrifugal Compressors for Oil Burning.

By S. A. Moss.

The use of crude or partially refined petroleum as fuel for industrial purposes is rapidly extending. Taking into account convenience and cleanliness, oil is a cheaper fuel than coal for many industrial purposes. For this reason oil is being used to an increasing extent for forging, hardening and tempering in blacksmith shops; baking cores and melting in brass, iron and steel foundries; smelting, melting and refining in metallurgical establishments, and for a great variety of other processes where high temperatures are desired.

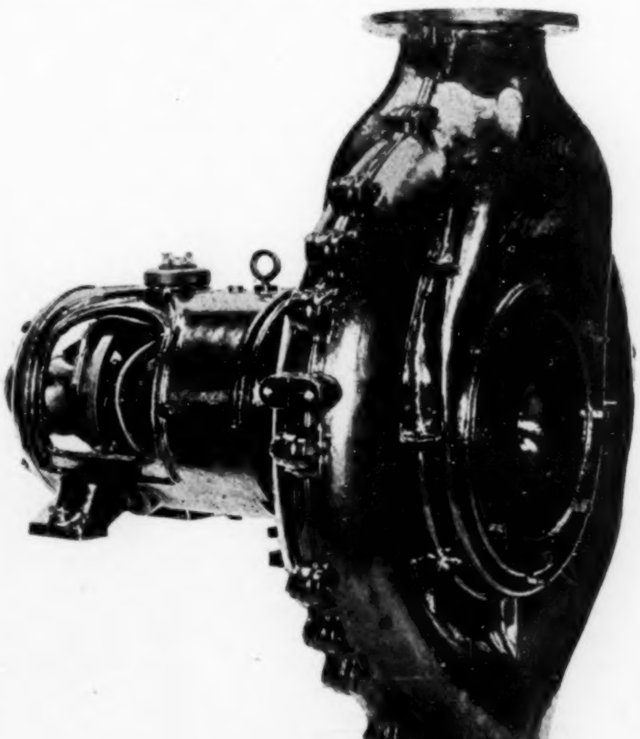
Oil is also used under steam boilers in many cases. However, space will not be taken for detailed discussion of this application.

The furnace usually consists of a chamber (often of very large dimensions), lined with fire brick, upon the floor of which is placed the object to be heated. The oil, together with some of the air for combustion, enters at one side from one or more jets, and the burning blast impinges on the object to be heated. Sometimes the chamber is rectangular, and the jets are directed immediately upon the object. In other cases there are bays or side chambers to give opportunity for complete combustion previous to the main chamber. There must, of course, be an outlet for the products of combustion after they have given up their heat. As can be seen, a furnace of this type is much simpler than one where coal is used as fuel, for with coal there must be a grate, a combustion chamber and an ash-pit. There is, in addition, the expense of firing, clinkering, and removal of ashes. Oil fuel is usually stored in tanks and delivered by pumps, and the storage and delivery is usually a simpler problem than that of coal.

So far as cost of a heat unit is concerned, coal is possibly a cheaper fuel at the present price of oil. However, taking into account all of the incidentals, the total cost with oil is in many cases much less.

Two kinds of oil are in use at the present time. One is crude oil just as it comes from the well, while the other is a residue remaining after some of the more valuable products have been extracted. The nature of this residue varies considerably at different places and at different periods.

In order that the oil may burn in a proper manner and in a reasonable space, without smoke, it must be intimately mixed with the air necessary for combustion. The oil is, therefore, reduced by a "burner" to very small drops, each surrounded by air for its combustion. This is called atomization. The drops must be of very small size, since a drop of appreciable size,



CENTRIFUGAL AIR COMPRESSOR.

even though it is surrounded by the entire amount of air necessary for its combustion, will proceed for a considerable distance from the burner, as a small ball of yellow flame, before it is completely burned.

The burners for producing the proper type of jet are of many shapes. There is always a pipe carrying oil under pressure leading through the burner. There is usually an additional pipe carrying compressed air or steam for the atomization. In the case of oil burners for steam boilers, the jet is usually steam, while for industrial purposes, the jet is usually compressed air. Some of the air for combustion is entrained or sucked in by the velocity of the jet issuing from the burner. In the case of steam atomization, the entire amount of air

must be supplied in this way. With air atomization the amount supplied under pressure and the amount entrained differ with the type of burner. There are many standard burners on the market and in addition many of the plants which burn oil have special devices of their own. The arrangements are, therefore, numerous and no general description can be given. There are the following general classes, however:

The compressed air may be supplied at a pressure from 15 lb. to 30 lb. per square inch. In such cases, the compressed air usually forms a comparatively small portion of that necessary for combustion, and the main air is entrained by the high velocity or sucked in by the chimney draft. In one such system, the main air is supplied by a forced draft given by a fan blower delivering the air through a pipe ending near the burner, at a comparatively low velocity.

In other cases, the compressed air is supplied at a pressure of from 1 lb. to 4 lb. per square inch. In these cases, probably the greater portion of the air is supplied, and a comparatively small amount is entrained. However, it is difficult to make a positive statement in this matter. The designers of the various burners usually have an idea regarding the amount of air to be supplied, althiugh this idea is often very approximate.

The General Electric Company have a standard line of single-stage centrifugal compressors from 5 hp to 350 hp for pressures of from 1 lb. to 4 lb. per square inch, and these are very well adapted for use with oil burners. Multi-stage machines are also made for pressures from 15 lb. to 30 lb. per square inch, and these have also been furnished for the same purpose.

These compressor sets are self-contained and are direct-driven by Curtis steam turbines, induction motors or direct-current motors. They have no wearing or rubbing parts and consequently, no matter how long they are in operation, there is no falling off in pressure and output due to leakage. The pressure is steady and free from pulsations.

Notes.

Colorado Iron Works Company's Impact Screen is the subject of a pamphlet, 9-B, issued from the Denver office. The screen is designed to take the place of trommels and hydraulic sizers in certain work. Recent minor improvements make the device thoroughly dependable for hard work.

Vanadium steels are now made in a variety of types suited to special purposes. Vanadium toughens steel directly by solid solution in the carbonless portion, and indirectly by removing oxides. The American Vanadium Company, Pittsburgh, has set forth qualities and uses of vanadium steels in a booklet recently issued. Test tables and microphotographs show the strength and structure of the steels. To extend their market, they have also recently published interesting pamphlets in French and German entitled Les Aciers au Vanadium and Vanadium Stahl respectively. Interesting information is given on the heat treatment of vanadium steels, the methods of employing vanadium in iron and steel, and results. Copies of these nicely illustrated books are sent to interested parties on request.

Power from Exhaust Steam may be obtained through turbine engines and greatly increases the efficiency of the power plant. The American Regenerator Company, Chicago, has explained in a pamphlet recently sent to us the operation and use of its regenerators for heat storage between the exhaust of reciprocating engines and the turbines.

Metal Statistics are neatly presented in a small volume of that title issued by the American Metal Market Company, New York. Iron and steel, copper, tin, spelter, lead, antimony, gold and silver are considered.

International Exhibition of Railways and Land Transport.—The Argentine Republic will celebrate the 100th anniversary of its political emancipation by an industrial exhibition to be held at Buenos Aires, May to December, 1910.

Ferroinclave, a sheet steel reinforcement for concrete work, is illustrated and described in a new catalog issued by the Brown Hoisting Machinery Company, Cleveland, Ohio. Ferroinclave is a sheet steel with dovetail corrugations, and is used in the construction of roofs, floors, walls, stairs, bridges, tanks, coal bins, etc.

Pneumatic Separators.—By the proper arrangement of air currents, deflectors and chambers all light, powdered materials may be handled with uniform results and remarkable precision. It is the design of Osborne pneumatic systems to accomplish this. These systems are adapted to removing waste from grinding machinery, separating and grading crushed products, washing dust from fuel gas, and neutralizing the fumes from chemical operations. A catalog of the Griscom-Spencer Company, 90 West Street, New York, explains in detail the operation of the Osborne system.

The Mineral Production of Canada for 1909 has been compiled and is being distributed by the Minister of Mines, at Ottawa.

Fire Brick.—A catalog received from the Scioto Fire Brick Company, Sciotoville, Ohio, describes high-grade fire-brick manufactured for various purposes. The analysis of the clay from which the brick are made shows it to be almost pure silicate of alumina.

Transite Asbestos Wood is a fireproof building material made by the H. W. Johns-Manville Company, New York. The material is mineral in character, but can be handled and worked just like wood.

The American Lava Company, Chattanooga, Tenn., manufactures machined insulating articles known to the trade as lava, but being in reality a talc which hardens upon being subjected to a high temperature. Quite a variety of insulators, gas burners, etc., are made in this manner.

Eimer & Amend, New York, have issued their 1910 edition of the catalogue of chemical apparatus. This is a very full and exceedingly interesting publication which should be in the hands of all users of chemical apparatus and chemicals.

The Ammonia-Cyanide Process for treating copper, gold and silver ores is a development by Western metallurgists who have organized the Ammonia-Cyanide Engineering Company, of San Francisco. The principle of the process is the leaching of ores, precipitating the dissolved copper by boiling out the ammonia in tight apparatus and then precipitating gold and silver by zinc dust or shavings in the usual manner. The ammonia boiled out of the solution is condensed for re-use.

The Control of Combustion in the boiler plant is the aim and object of the Sarco CO_2 recorders, made by the Sarco Fuel Saving & Engineering Company, of New York. A recent catalog describes their device for automatically recording the CO_2 in the flue gases. Other catalogs deal with the company's pyrometers, calorimeters, recording draught gages and recording steam meters.

The New York Metal Exchange has issued its statistical review of the domestic and foreign metal markets for 1910. The production and prices of tin, copper, lead, spelter, iron and steel, antimony and silver in the various markets of the world are given.

Water Gage Glasses break from contact with cold drafts of air or liquids while the glass is heated. A new German gage glass, known as "Sonderglass," is made by fusing two separate tubes into one, thereby giving increased strength and allowing for expansion and changes of temperature. A. W. Chesterton Co., Boston, are importers into this country.

Ozone.—As an instance of the progress which ozone is now making in water sterilization it may be mentioned that the city of St. Petersburg, in Russia, has installed an ozone plant for the treatment of 10,000,000 gal. of water a day. The system of ozone generation of the Siemens & Halske Company is being used. Further progress is also reported from several German and Austrian cities. Ozone ventilators for the purification of air in rooms are stated to find increased favor.

Cupel Machine.—The Denver Fire Clay Co., of Denver, Col., has sent us a description of Iler's cupel machine, which with the improvements recently made, has a capacity of 500 cupels per hour. It is operated by foot power, and the density and thickness of the cupels are regulated by one small set-screw on the pedal. The Iler cupel machine is made in two sizes, one making 1¼-in. and 1½-in. cupels, and the other making, 1¼-in. 1½-in. and 2-in. cupels.

Liquid Chlorine.—While in former years the liquid chlorine used in this country for various chemical and metallurgical purposes was imported from Germany, various American manufacturers have taken up the manufacture of liquid chlorine during the last year. Among them are the Castner Electrolytic Company, the Hooker Electrochemical Company, the Electro Bleaching Company and the Goldschmidt Detinning Company. From a statement of the Electro Bleaching Company we learn that they are entering the market prepared to supply any quantity of liquid chlorine from 100 lb. up to carload lots—18,000 lb. minimum. It is shipped in steel cylinders or drums holding approximately 100 lb. each.

Concrete Mixer.—We have received from the Chain Belt Company, of Milwaukee, Wis., their illustrated catalog 39, giving details of construction of their chain belt concrete mixer. This is a "batch" mixer of the "non-tilting" or chute-discharge type. A power loader is employed instead of the standard charging hopper. While the Chain Belt concrete mixers are furnished with steam, gasoline or electric power as desired, steam is thought to be the most reliable and economical under general conditions.

Combination Induction Furnace.—The firm of Pilger & Neidhart, in Frankfurt-Bockenheim, Germany, is erecting a combination induction furnace of the Roechling-Rodenhauser type for the manufacture of steel castings from electric steel.

New Blast Furnace.—The new furnace of the Andrew & Hitchcock Iron Company, Hubbard, Ohio, was successfully blown-in on Feb. 19, this year. This is the first of the new furnaces to go into operation this year. It is the latest type of furnace, designed and built by Mr. Julian Kennedy, of Pittsburgh, Pa., and Mr. Arthur E. L. Dette, engineer in charge of construction. The William B. Pollock Company, Youngstown, Ohio, furnished the iron work, and the Stowe-Fuller Company, of Cleveland, Ohio, all the firebrick. Niles brick were used for furnace lining, National brick for the stoves, and Empire brick for pipes and connections. The furnace, stoves, and connections make one of the best and most complete blast-furnace plants in the Mahonning Valley.

Industrial Engineering and the **Engineering Digest** have been consolidated into one paper under the name *Industrial Engineering and the Engineering Digest*.

The **Schaeffer & Budenburg Manufacturing Company,** 963 Kent Avenue, Brooklyn, N. Y., have sent us their catalog on indicating and recording pressure and vacuum gages, ammonia gages, hydraulic gages, draft gages, etc. Among the gages described is a new draft gage which indicates a pressure or draft of 1/100 in. of water column. It is fitted with a large, easily read dial.

California Mining Bulletin.—The California State Mining Bureau has just issued a bulletin dealing with the mineral productions and mining laws of that state. There is also included a set of county maps.

Pacific Smelting and Mining Company has issued to its stockholders the first annual report, showing the property owned by the company and the status of development. The company's office is 42 Broadway, New York, and the mines and smelter are located at Fundicion, Sonora, Mexico.

The United Iron Works Company, Springfield, Mo., has recently issued a catalog of concentrating machinery. General milling machinery for ore-dressing is described and illustrated. The company makes a specialty of electromagnetic separators and manufactures the Cleveland-Knowles separator.

Electrostatic Ore Separation is the title of a booklet which we have received from the Huff Electrostatic Separator Company, Boston. A brief explanation of the principles and application of electrostatic separation of minerals is given. This interesting new separator will be described in detail in our next issue.

Testing and Research Laboratories of E. S. Lincoln, Brookline, Mass., are described in a booklet which he has just issued. Testing and research work of any description in the electrical field is undertaken.

The Pacific Tank Company and the **National Wood Pipe Company** announce a business consolidation under the name of Pacific Tank & Pipe Company. The company has factories on the Pacific Coast, and offices in the Equitable Bank Building, Los Angeles, Cal. A new factory has just been completed at Portland, Ore., which is the largest of its kind.

The Year-Book for Colorists and Dyers, published by Herman A. Metz, New York, has been received at this office. The book contains much very useful information of interest to the trade.

Oxygenite is an electrolytic product in the form of a gray pulverulent mass resembling fine sand and possessing the property of releasing when heated all of its contained oxygen. This amounts to about 5¼ cu. ft. of gas per pound of oxygenite. The material burns slowly, without a flame, and can be kept almost indefinitely, even if exposed to the atmosphere, without deterioration. It is valuable for generating oxygen for oxy-acetylene welding plants without having recourse to buying compressed oxygen in tubes. The oxygenite process and the machinery used in its application are controlled by the Industrial Oxygen Company, New York.

Davis-Bournonville Company reports a great advancement in cutting steel by the oxy-acetylene process. A 6-in. steel shaft requires 3 minutes to cut at a cost of about 37 cents. A 3½-in. steel plate has been cut 18 ft. in 26 minutes, and a 6-ft. cut was made in ⅝-in. steel in 2 minutes and 29 seconds. Other excellent performances consisted in cutting 84 ft. of ¼-in. steel in one hour, and a circle of 19½ in. circumference out of 1-in. plate in 45 seconds.

Export Office Opened.—The General Fireproofing Company, of Youngstown, Ohio, has opened an export office at 396 Broadway, New York City, in charge of Mr. A. D. Level, who has been for several years with the United States Steel Products Export Company.

Cyanide Plant Opens.—The old mill of the Natividad y Anexas Mining Company in the Sierra Juarez district, State of Oaxaca, Mexico, has been closed down and the ores will be treated by the new cyanide plant, which has just been finished.

Forge Shop Furnaces.—The W. S. Rockwell Company, of New York City, have sent us their catalog No. 8, on their forge shop furnaces operated with oil or gas fuel, for forging, flanging, plate heating, angle-bending, spring-fitting, case-hardening, tempering, annealing, etc. The catalog gives data on the various sizes in which these furnaces are made, with diagrams showing their construction.

Nationality of Inventors of Electric Steel Furnaces.—In a recent lecture on electric steel furnaces the following somewhat amusing remark was made by Mr. Viktor Engelhardt, chief engineer of the Siemens & Halske Company: "The inventors of the most important arc furnaces for steel making are Frenchmen like Heroult and Girod, or Italians like Stassano. The inventors of the induction furnaces are of the Teutonic or Anglo-Saxon races: Kjellin, Frick, Gronwall are Swedes; Colby, an American; Roechling and Rodenhauser are Germans. One might make the paradoxical remark that the types of the furnaces are in conformity with the race characteristics of the inventors. The arc furnaces spark with a noise and brilliant flame suggesting more fire than there is really in them. The induction furnaces behave in the reverse way. Their cooler outside appearance does not suggest at once how much heat is available in their interior."

Personal.

Dr. **Richard Amberg**, formerly manager of a carborundum company in Southern Switzerland, is now connected with the Indiana Harbor, Ind., plant of the American Steel Foundries, where an electric steel furnace is in operation.

Mr. **A. J. Bettles**, of Salt Lake City, has resigned his position as consulting metallurgist to the Utah Copper Company, and expects to devote his time to private interests. He has been closely identified with the progress of metallurgy, and particularly ore dressing, in Utah for a quarter of a century.

Mr. **J. W. Coyle**, who was connected with the Best American Calorific Company until they retired from business, is now with the Rockwell Furnace Company, making a specialty of oil and gas furnaces for railroad work. Mr. Coyle is an experienced railroad man, having formerly been master blacksmith for the Lehigh at Wilkes-Barre, and later in charge of the drop-hammer and machine department at the forge shops of the Reading, at Reading, Pa.

Mr. **J. V. N. Dorr**, metallurgical engineer of Denver, and the inventor of the classifier and pulp thickener known by his name, has recently been in San Francisco on professional business.

Mr. **L. C. Hammond**, formerly at the head of the sales staff of the Denver Engineering Works, has accepted a similar position with the Central Colorado Power Company. Mr. P. D. Grommon has been placed in temporary charge of Mr. Hammond's work.

Mr. **Lafayette Hanchett**, formerly of Colorado, but later identified with the Newhouse interests in Utah, has left for an extended world tour, having sailed from San Francisco last month.

Mr. **H. W. Hardinge**, the inventor of the Hardinge conical-tube mill, of New York City, is on a professional trip and will visit the Lake Superior copper district and the famous Cobalt, Canada, silver district.

Mr. **C. A. Heberlein** has recently returned to the City of Mexico from an outlying district, where he has been erecting a smelting plant.

Mr. **A. B. W. Hodges**, who has for some years been general manager of the Granby Consolidated Company in British Columbia, has recently resigned his position, and will assume the general managership of the Cerro de Pasco Mining Co. in Chile.

Mr. **D. C. Jackling**, manager of the Utah Copper Co., has left Salt Lake City on a trip to Colorado Springs, from which place he will go to Ray, Ariz., to inspect some copper properties.

Mr. **E. M. Johnson** has recently resigned his position as metallurgist at the Collinsville, Ill., plant of the St. Louis Smelting & Refining Company.

Mr. **F. H. Nickle** has resigned his position as engineer for the Pennsylvania Salt Manufacturing Company, at Wyandotte, Mich., and will specialize in vacuum evaporating work and salt-plant engineering. Mr. Nickle is associated with the firm of McDonald & Nickle, with headquarters at Detroit.

Mr. **W. H. Oldham** has recently been appointed general blast-furnace superintendent for the Birmingham Coal & Iron Company, Birmingham, Ala.

Mr. **William Scallon**, who formerly resided at Butte, Mont., where he was president of the Anaconda company and Western manager of the Amalgamated company, has removed to New York, where he will be permanently located at Hotel Netherland. Mr. Scallon will engage in the practice of law and will have no connection with the companies mentioned.

Mr. **Charles F. Shelby**, formerly with the Phelps-Dodge Company in Arizona, and later superintendent at the Greene-Cananea, in Mexico, has accepted a position as smelter manager with the Cerro de Pasco Company, in Peru.

Mr. **E. R. Wooley**, president of the Utah Ore Sampling Co., has returned to Salt Lake City, from an Eastern trip.

Digest of Electrochemical U. S. Patents.

Prior to 1903.

Arranged according to subject matters and in chronological order.

Compiled by Byrnes, Townsend & Brickenstein, Patent Lawyers, National Union Building, Washington, D. C.

ELECTRIC FURNACES (*Continued*)

657,202, Sept. 4, 1900, H. C. McBrair, of Middletown, N. Y.

Resistance type. A dental furnace for firing porcelain, in the form of a box having a hinged cover. The joint between the base and cover lies in a plane inclined downward toward the front. The base and cover are of metal lined with fireclay. A platinum resistance-wire is embedded in the inner face of each part. Contact springs and pins connected with the hinges complete the circuit.

657,911, Sept. 18, 1900, G. D. Burton, of Boston, Mass.

Resistance furnace for reducing ores containing gold, silver, sulphur and arsenic. The current used is from 6000 amp to 7000 amp at from 4 volts to 16 volts. The furnace has a vertical resistor chamber surmounted by a short stack, both consisting of carbon or of an alloy of copper, three parts; antimony, two parts, and tin one part. The upper and lower ends of the chamber are surrounded by massive clamps of copper, serving as terminals. The lower clamp has a plate closing the lower end of the furnace, and is hinged to drop down. The chamber is surrounded between and above the electrodes with clay, and may be lined with clay. An inclined feed-pipe opens into the stack. This pipe and the stack are closed by caps. Pipes serve for the introduction of steam and air, to assist combustion and chemical action. A pipe leading to an eduction-pump and water condenser serves to draw off sulphur and arsenic vapors. The furnace has steam and air gages and a pyrometer. Combustible matter may be mixed with the ore charge. By gradually raising the temperature of the charge, lead, silver and gold, or lead, antimony, zinc, etc., may be successively smelted and separately drawn off. The furnace may be used for separating bullion and for producing calcium carbide.

658,315, Sept. 18, 1900, A. H. Cowles, of Cleveland, Ohio.

Arc or resistance type. The electric furnace proper is a chamber with solid carbon walls, constituting one electrode, and receiving a depending carbon electrode. The depending electrode is adjustably carried by a water-cooled stem passing through a stuffing-box. Ore-hoppers with double valves open into the top of the chamber. At each side of and connected with the smelting chamber are chambers with carbon walls, receiving coke supported on a grate beneath. Each side chamber communicates with hot-blast stoves or regenerators for supplying heated air and gas. Valved fuel-hoppers open into the upper ends of the side chambers. The walls and hoppers are water-jacketed and cooling coils may be embedded in the walls and cover. In operation, heated air and gas are introduced into one side chamber and pass through the body of coke therein, effecting combustion. The products of combustion then pass through the charge of ore in the intermediate electric furnace, preferably not through the zone of highest temperature, and thence through the body of coke in the other side chamber, escaping to the regenerators. The flow of gas and air is periodically reversed. The furnace may be used to reduce "lime, clay, sand, aluminium, etc."

658,536, Sept. 25, 1900, G. M. Westman, of New York, N. Y.

Resistance type. Furnace for treating ores containing arsenic and precious metals. The furnace chamber is of fire-clay, with a removable lid carrying a valved hopper. The smelting chamber is a trough, the bottom of which is recessed at each end to receive water-cooled cast-iron electrodes. The exposed upper ends of these electrodes may be curved to the shape of parabolas, to increase contact with the ore. The charge, which

may be an arsenical ore containing iron, e. g., mispickle, carries the alternating current and is heated thereby as a resistor. The liberated arsenic escapes through a pipe to settling chambers and a water condenser. The melted ore free from arsenic, molten iron sulphides, or mattes, are tapped off. Much of the gold and silver sinks downward and may be absorbed by pools of lead over the electrodes.

658,698, Sept. 25, 1900, C. S. Bradley, of New York, N. Y.

Modification of furnace shown in patent 597,945, especially designed for the production of cyanides from carbides. The furnace is of the wheel type, carbon electrodes of opposite polarity depending into one side of the annular rim constituting the receptacle. Pipes for supplying nitrogen to the carbide extend outward from the hollow shaft to the rim at different points. A valve in the hollow shaft, or separate valves in the several pipes actuated by fixed tappets, supply nitrogen to the carbide from the time of its formation until it cools below the point at which further absorption will take place.

NEW BOOKS.

Allen, Alfred H. Commercial organic analysis; treatise on the properties, modes of assaying, and proximate analytical examination of the various organic chemicals and products employed in the arts, manufactures, medicine, etc.; with concise methods for the detection and estimation of their impurities, adulterations and products of decomposition. Vol. 1, fourth edition, entirely rewritten. Edited by H. Leffmann and W. A. Davis. Illustrated. Price, $5.00 net. Philadelphia: P. Blakiston's Sons & Co.

Armes, Ethel. Story of coal and iron in Alabama. Illustrated. Price, $5. Alabama Chamber of Commerce.

Ball, W. V. Law affecting engineers. 300 pages. Price, $2 net. New York: D. Van Nostrand Company.

Ballinger, W. F., and Emile G. Perrot. Inspector's handbook of reinforced concrete. Price, $1.00. New York: Engineering News.

Bardwell, Fred Leslie, and Elwood B. Speer. Laboratory experiments in inorganic chemistry. Compiled from various sources for the use of students of the Massachusetts Institute of Technology. Price, 75 cents. Boston: F. L. Bardwell.

Bartley, Elias Hudson. Text book of medical and pharmaceutical chemistry. Seventh edition, revised 1909. 749 pages, illustrated. Price, $3. Philadelphia: P. Blakiston's Sons & Co.

Blaine, Robert Gordon. Calculus and its applications. Practical treatise for beginners, especially engineering students. Price, $1.50 net. New York: D. Van Nostrand Co.

Breckenridge, Lester Paige, and Paul Diserens. Fuel tests with Illinois coal. (Comp. from tests made by the Technological Branch of the United States Geological Survey, at the St. Louis fuel testing plant, 1904, June 30, 1907). Fifty-four pages, illustrated, tables and diagrams. Urbana, Ill.: University of Illinois.

Cambria Steel Co. Cambria Steel: handbook of information rel. to structural steel manufacture by the Cambria Steel Co., containing useful tables, rules, data and formulae for the use of engineers, architects, builders and mechanics; prepared and compiled by George E. Thackray. Ninth edition. 484 pages. Price, $1.00. New York: Cambria Steel Co.

Durkee, F. W. Experiments in general inorganic chemistry. Second edition, revised. Price, 50 cents. Tufts College, Medford, Mass.

Gillette, Halbert Powers, and R. T. Dana. Cost keeping and management engineering; treatise for engineers, contractors and superintendents engaged in the management of engineering construction. Price, $3.50. Chicago: M. C. Clark Publishing Co.

Gissing, F. T. Commercial peat, its uses and its possibilities. Price, $2.00 net. Philadelphia: J. B. Lippincott Co.

Gregory, R. Arman and H. E. Hadley. Class work of Physics. Price, $1.00 net. New York; Macmillan Company.

Grover, F. Modern gas and oil engine. Fifth edition. Price, $2. New York: Spon & Chamberlain.

Grünwald, Julius. Enameling on iron and steel. Price, $2.00 net. Philadelphia: J. B. Lippincott Co.

Henderson, J. Electrotechnics. (Physical and electrical engineering laboratory manuals.) Price, $1.20. New York, Longmans, Green & Co.

Latta, M. Nisbet. American producer gas practice and industrial gas engineering. Price, $6.00 net. New York: D. Van Nostrand Co.

Lunge, G. Coal, tar and ammonia. Two volumes. Fourth edition. 1210 pages, illustrated. Price, $15.00 net. New York: D. Van Nostrand Co.

Lunge, G. Manufacture of sulphuric acid and alkali; theoretical and practical treatise. Vol. 2: Sulphate of soda, hydrochloric acid, Leblanc soda. Third edition, much enlarged. 1044 pages, illustrated. Price, $15.00 net. New York: D. Van Nostrand Co.

Morgan, J. J. Blast furnace practice. Price, 75 cents net. Philadelphia: J. B. Lippincott Co.

Morsch, Emil. Concrete steel construction (Der Eisenbetonbau); authorized translation from the third (1908) German edition, revised and enlarged by E. P. Goodrich. Price, $5.00. New York: Engineering News.

Munroe, C. E., and Clarence Hall. Primer on explosives for coal miners. 61 pages. (U. S. Dept. of the Interior, U. S. Geological Survey Bull.) U. S. Supt. of Docs.

Normandy, Fk. Sea Water Distillation. Price, $2.00 net. Philadelphia: J. B. Lippincott Co.

Sharpe, T. Modern Foundry Practice, including molding, materials used, machinery and appliances, etc. Second edition. Price, $8.00. New York: Spon & Chamberlain.

Shelford, F. Pioneering for engineers; including most suitable camp equipment, rations, medicines, clothing, etc. Price, $1.25. New York: Spon & Chamberlain.

Sudborough, J. J., and J. C. James. Practical organic chemistry. 394 pages, illustrated. Price, $2.00 net. New York: D. Van Nostrand Company.

Stewart, R. Wallace. Elementary text-book of physics. Price, $1.50 net. Philadelphia: J. B. Lippincott Co.

Suplee, H. Harrison. Gas turbine. Progress in the design and construction of turbines operated by gases of combustion. Price, $3.00 net. Philadelphia: J. B. Lippincott Co.

Tutton, A. E. Howard. Crystalline structure and chemical constitution. Price, $1.60 net. New York: Macmillan Company.

Tyrell, H. Gratton. Concrete bridges and culverts for both railroads and highways. Price, $3.00. Chicago: M. C. Clark Publishing Company.

BOOK REVIEWS.

Producer-Gas Fired Furnaces. By **Oscar Nagel.** Ph.D. 8vo., 192 pages, 237 illustrations. Price, $2 net. New York City: The Author (P. O. Box 385).

Intended as a hand-book giving detailed descriptions of these furnaces, it only measurably achieves its object. While the book is in parts commendably written and illustrated, yet other parts are unsatisfactory both in manner of presentation and illustration, while the style, as written English, is faulty throughout. The scientific explanations, where ventured upon, are mostly of doubtful accuracy.

The author is most at home in describing the furnaces used in the lime, cement, brick, ceramic, glass and chemical industries, and in respect to these the book will certainly be found useful; the furnaces used in non-ferrous metal industries are fairly well treated; the furnaces used in the iron and steel industry are poorly handled, the author often showing igno-

rance of the purpose or mode of operation of some particular furnace (e.g., furnace shown in Figs. 77-81).

In describing producers themselves, some blunders occur which decrease the value of the information. The Bildt automatic feed, for instance, is labeled the "Morgan Producer." We cannot consider this chapter as of much value; it is rather a heterogeneous compilation.

Altogether, the subject is neither exhaustively nor equably treated; the book might have been much better. Parts contain useful information which make the book worth while; it is, however, neither scientifically accurate nor otherwise always reliable.

* * *

Modern Coking Practice. By **T. H. Byron** and **J. E. Christopher.** 8vo, 109 illustrations and diagrams, 168 pages. Price 8/6 (in New York, $3.50). London: Crosby, Lockwood & Son.

This is an eminently practical, condensed, well-written work, thoroughly up to date. The authors are chief chemist and submanager, respectively, of the Wigan Coal & Iron Company, and in practical charge of an extensive Semet-Solvay coking plant. The sampling and valuation of the coal and coke, and working up of the by-products, are treated in the same business-like manner as the main subject—the construction and operation of the ovens. The book is recommended to all interested in this subject.

* * *

The Chemistry of Cyanide Solutions. By **J. E. Clennell,** B.Sc. Second edition. 8vo., 202 pages. Price, $2.50 net. New York: McGraw-Hill Book Company.

A second edition of this useful book will be received with pleasure by all who have used the first edition of the work; it is an eminently practical laboratory guide to the metallurgical chemist in charge of a cyanide plant. We would recommend the chemist, however, to use the book as a nucleus about which to accumulate notes of other analytical cyanide methods as they appear from time to time. In that way a complete laboratory guide can be constructed which will put the metallurgist abreast of the best practice of his profession in this line.

* * *

Die Herstellung von Hochprocentigem Ferrosilizium im elektrischen Ofen. By Dr. Ing. **Waldemar Pick** and Dr. Ing. **Walter Conrad.** 8vo., 144 pages, 26 illustrations. Price 6.60 marks. (Retail price in New York, $2.15.) Halle a. S., Germany: Wilhelm Knapp.

This monograph on the electric furnace production of high-percentage ferro-silicon is an amplification of the doctor's thesis presented by the authors at the University of Vienna. It contains more detailed and more exact information upon this subject than is to be found anywhere else. The student of electrometallurgy, the electric furnace expert, the manufacturer of ferro-silicon, and the user of the same, will all find the work full of interesting and valuable information.

A short introduction gives the older metallurgical literature on "silicon pig" iron or "glazed pig." A longer chapter describes the recent researches on the silicides of iron, and gives the phase diagram or equilibrium diagram of the various mixtures of iron and silicon, followed by a description of the commercial ferro-silicons.

The spontaneous crumbling of ferro-silicon containing 30 to 65 per cent silicon is next discussed. This is an important topic, because of the decreased market value of such powdered material. Sometimes two samples from the same furnace, with identical analysis, will behave differently, one crumbling and the other not. Their conclusion is that the crumbling is due to a crystalline decomposition, caused primarily by two rapid or too slow setting from the melted condition.

Another interesting subject discussed is the explosiveness of some ferro-silicons, and the poisonous gases given off by others. The explosions are ascribed to gases, like acetylene or silicon hydride, given off by the action of atmospheric moisture and ignited by sparks caused by the attrition of the pieces against each other as the material is moved. The gases are given off particularly by 40 to 60 per cent ferro-silicon, and can be avoided by soaking the material in water or passing steam through it, and then not packing it until it has been thoroughly dried.

Another remedy suggested is to forbid the shipping of 40 to 60 per cent ferro-silicon.

Eight pages are given to the chemical analysis of these alloys, in which the authors give the methods which they have found most reliable.

A sixteen-page chapter describes the various electric-furnace processes which have been proposed and used for making ferro-silicon. The connection of the rise of this industry with the historic "slump" in the calcium carbide business is dwelt upon. The patents of Price and Tone are not very appreciatively mentioned.

There then follow the three most valuable chapters in the book: One of 37 pages on the construction and operation of an electric furnace ferro-silicon plant, another of 8 pages on the theoretical work done in the production of these alloys, and a third of 21 pages on the useful effect and practical efficiency of furnaces in actual operation.

In the chapter on construction and operation of plant, the details are minute and satisfactory; the person following them, however, would need to carefully consider to what extent he might be infringing patented apparatus and methods.

In the calculation of the theoretical work necessary for producing different grades of ferro-silicon, Dr. Henry Noel Potter's determination of the heat of oxidation of silicon, 7595 calories per gram, is taken as the most reliable. With this we agree, but we cannot agree to take Thomsen's value for the heat of oxidation of carbon to monoxide, 2183 calories per gram, which is in error at least 10 per cent; Berthelot's value of 2430 is much more probably correct. The gases escaping from the furnaces are assumed at 700° C, the alloys at 1500° to 2000°, the specific heat of silicon as averaging 0.29, its latent heat of fusion (probably 128 calories) is neglected. With these conditions, a minimum power requirement of 321 kw-days is calculated per ton of silicon. Working with partly un-enclosed arc, the escaping gases are assumed to be at 2000°, and the minimum power requirement is 358 kw-days. For various grades of ferro-silicon the minimum power requirement using metallic iron in the furnace is calculated per ton of product in kw-days as:

	With Enclosed Arcs.	Un-enclosed Arcs.
25 per cent ferro-silicon..............	88 (130)	97 (150)
50 " " "	165	184

The kw-days given above in parenthesis indicate the minimum power requirement calculated for using iron oxide in the furnace instead of metallic iron.

The investigation of actual furnaces to determine their efficiency gives very interesting results. The net efficiency is only 40 to 50 per cent, the 60 to 50 per cent list being accounted for by radiation and conduction and the vaporization of silica, in the ratio of about 20 per cent to the former and 30 per cent to the latter. The heat required to heat cold SiO_2 to the vaporizing point and vaporize it is taken as 843 calories per gram. One conclusion reached is that at least 2 kg of silicon can be obtained per kw-day, and better results than this have been obtained.

The concluding chapters deal with the influence of the voltage, current used, and impurities present, on the output of silicon and on the purity of the alloys obtained.

As a whole, the book is a highly interesting contribution to electrometallurgical literature, and we congratulate the authors upon their splendid work.

J. W. RICHARDS.